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AN EXAMINATION OF RISK: AN APPLICATION TO
AGRICULTURAL PUBLIC RISK PROGRAMS

by

RAY BLOCK

A PROJECT

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTERS OF AGRICULTURE

IN

AGRICULTURAL ECONOMICS

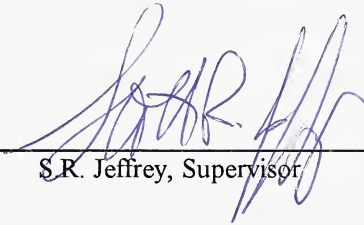
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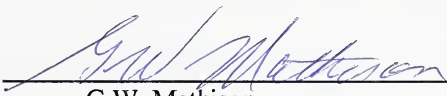
The undersigned certify that they have read, and recommend to the Department of Rural Economy, for acceptance, a project entitled AN EXAMINATION OF RISK: AN APPLICATION TO AGRICULTURAL PUBLIC RISK PROGRAMS submitted by Ray Block in partial fulfilment of the requirements for the degree of MASTER OF AGRICULTURE in AGRICULTURAL ECONOMICS.



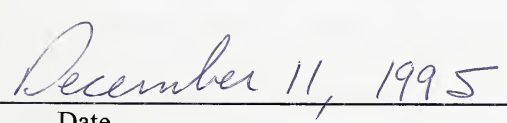
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ABSTRACT

This paper provides, through a review of relevant literature, a discussion about risk as it pertains to public risk programs in agriculture. Three specific objectives are specified: defining and explaining the term risk as it applies to public risk programs, reviewing methods of risk measurement, and applying the tools of portfolio theory to public risk programs.

For the purposes of this study, risk is defined as the variability of returns, as public risk programs tend to be concerned with reducing the variability of producers' incomes. This definition allows the use of a mean-variance model in quantifying risk. The study further indicates that the sources of public risk can be grouped into five categories: production risk; market or price risk; technological risk; legal and social risk; and human sources of risk.

In achieving the second objective, various risk measures are identified, including the variance, standard deviation, covariance and the correlation coefficient. It is observed that some risk groupings are quantifiable while others are not. The portfolio model is examined as an approach which can be used to identify a set of risk efficient stock portfolios from among all of the available securities within the marketplace. From portfolio theory, it is determined that the effectiveness of diversification as a risk management strategy is greatly influenced by the magnitude and sign of the correlation coefficient between individual investments.

From investment theory, components of total variability are described in terms of systematic and non-systematic risk. The importance of this concept is twofold. First, an effective diversification strategy can reduce the unique risk (i.e., non-systematic risk) and thus the cost of some public risk programs. Second, the systematic risk common to all

farms is the risk which public programs should be designed to address. Cost estimates of these programs and some key program management issues can be evaluated using the concept of systematic risk. The final risk measurement tool identified is the single-index model. This model assumes that the residuals for the different stocks are perfectly uncorrelated, allowing for an accurate estimate of the minimum variance.

For the final study objective, a review of portfolio theory for application to public risk programs is conducted. The three applications examined are crop insurance, area-yield options and companion stabilization programs. Problems within individualized crop insurance (i.e., rising costs, dropping participation, moral hazard and adverse selection) led Miranda to revisit area-yield insurance. Through the use of portfolio theory and specifically the ideas of systematic risk, an alternative area-yield insurance is proposed as a way of addressing these problems.

The second application considered is related to crop insurance and risk management tools which are available to insurance providers. The specific tool is an area yield options contract, traded on public markets. This contract could be used to manage the yield risk accepted by insurance providers. Again it is seen that portfolio theory can be used to evaluate and measure that potential.

The third and final application reviewed is public revenue stabilization schemes currently being considered in Canada under the heading of companion risk programs. As in the previous cases, this program involves potential claims to the program provider contingent upon uncertain income realizations from farming activities. As before, the program administrators is concerned with evaluating the potential payments which they may be required to make to their clients. Again, by understanding the characteristics of a portfolio, a reasonable estimate of future claims can be developed.

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Section 1 Introduction

Adam Smith observed that "insurance, by dividing among a great many that loss which would ruin an individual, makes it fall light and easy upon the whole society." (Smith 1937, 715) This loss or risk has both systematic and nonsystematic components. The differentiation between these two components has long been considered in portfolio theory but more recently has emerged within the agricultural economics literature.

Administrators of agricultural public risk programs are faced with the challenge of providing more cost-effective, taxpayer friendly crop insurance and companion programs for their clientele. Recent budget deficits have spurred an interest in reviewing the programs and products which are currently offered in Canada. This inquiry has led to a National Crop Insurance Review, the introduction of whole farm income stabilization programs, the elimination of commodity specific support, and a reduction in input subsidy programs.

The purpose of this project is to review risk literature to see how it can be applied to public risk programs including crop insurance and proposed safety nets. Potential changes to existing programs such as the current individualized coverage crop insurance and the development of new programs will also be considered.

1.1 Study Objectives

There are three specific objectives to be achieved within this study. First, the term "risk" will be defined and explained as it applies to agricultural public risk programs. Given the resulting definition, appropriate methods of risk measurement are reviewed. Finally, portfolio theory is discussed in terms of its potential application in the design, management and evaluation of public risk programs, including crop insurance and proposed safety nets.

1.2 Study Plan

The remainder of this report is comprised of three sections. Section 2 provides the conceptual and methodological background for the study. Risk is defined and other concepts necessary to evaluate risk management programs are identified and discussed. Section 3 applies the principles and theory to a number of public risk programs including crop insurance and companion stabilization programs. Finally, a summary of results and conclusions as well as suggestions for future research are presented in section 4.

Section 2 A Discussion of Risk and the Portfolio Model

The word risk is used in many circumstances and has many definitions. The discussion in this study requires a definition of risk that may be applied to agricultural public risk programs.

2.1 Risk Defined

Denenberg suggests that risk is the "uncertainty of loss . . . it is a psychological phenomenon that is meaningful only in terms of human reactions and experiences." (Denenberg et al 1964, 4) Riegel and Miller characterize risk as the "probability of an unfortunate occurrence." (Riegel and Miller 1966, 20) Greene similarly defines risk as "uncertainty as to the occurrence of an economic loss." (Greene 1962, 2) The Committee on General Terminology of the American Risk and Insurance Association has approved two definitions of risk; "uncertainty as to the outcome of an event when two or more possibilities exist "and "a person or thing insured". (Mehr and Gustavson 1987, 22)

A statistician might define risk as the degree of dispersion around the average or expected value for a particular distribution. Greater degrees of dispersion represent greater levels of risk. Vaughan and Vaughan define risk as "a condition in which there is a possibility of an adverse deviation from a desired outcome that is expected or hoped for." (Vaughan and Vaughan 1995, 5) This definition incorporates the notion of variability of returns and that the presence of risk implies that more than one outcome is possible. From these definitions emerges a common theme. Definitions such as the probability of an unfortunate occurrence, adverse deviation and uncertainty of outcomes all point to the variability between expected and actual returns.

For the purposes of this study risk will be defined as the variability of returns since public risk programs tend to be concerned with reducing the variability of producers' incomes. This definition embraces the common theme which is found in most of the previous definitions, and is consistent with the mean-standard deviation, or mean-variance criterion. This criterion suggests that the decision as to the "best" alternative should be based on the calculated means and variances of returns. Therefore one decision maker may prefer an alternative with a higher expected return for a given level of variance while another may choose an alternative with a lesser expected return with a corresponding decreased variance. This idea will be expanded in the following sections.

2.2 Risk Categories

Within the business of farming, the producer must consider a whole array of risks when managing his/her operation. The sources of these risks can be grouped into five categories, as follows: "(1) production or technical risk; (2) market or price risk; (3) technological risk; (4) legal and social risk; and (5) human sources of risk." (Sonka and Patrick 1984, 97) This section contains a brief description of these different risk sources and how they apply to the provision of public risk programs.

2.2.1 Production Risk

Weather hazards such as drought, excessive moisture, hail, frost, wind, snow, and fire caused by lightning are examples of production risk. The threat of plant disease and insect infestations can also be included within this risk category. Crop insurance is a risk management tool that is available to producers who wish to have some protection against the potential economic loss inflicted by these risks.

Damage to agricultural crops inflicted by waterfowl and wildlife could also be included in this risk grouping. Compensation for wildlife damage is typically provided at no cost to an owner/operator or tenant operator of a farm in Alberta who experiences losses due to this risk. Although wildlife damage will not be considered in the discussion within this report, it is important for administrators of other public risk programs to guard against compensating producers twice for the same loss (i.e., double indemnity).

2.2.2 Market or Price Risk

Credit risks, including securing adequate finances and the threat of fluctuations and variability of interest rates, are included under this risk grouping. Numerous credit stabilizing products and diversification strategies can be considered by the farmer in the management of this risk.

Market risk also includes the lack of an available market for the producers' production, the possibility of a market price that will not allow for a return on investment, and unanticipated losses due to currency fluctuations. The national gross revenue insurance program (i.e., GRIP) was intended to address the market price problem for those farmers who elected to buy this type of crop insurance. While providing a measure of market price protection, the program also provided security for yield loss. To avoid the double indemnity problem, a deduction was imposed for deemed or actual "all risk" crop insurance payments.

2.2.3 Technological Risk

The technological evolution of agricultural production is a never ending process. The development from human labor to animal assisted labor to tractor power is an

example of this evolution. Advances in transportation and storage technology are further examples. The producer who does not keep up with these technological changes runs the risk of becoming non-competitive. Extension programs offered by various government agencies are intended to assist the producer in keeping up with some of these changes.

2.2.4 Legal and Social Risk

The individual farmer's decisions, as well as societal policies that affect the producer's production decisions, can change the natural environment. As a result, the producer faces potential economic loss should damages occur to the environment. A recent Price Waterhouse study concludes that "complete individual coverage should be adopted as soon as possible. This ensures that incentives for producers to undertake practices which will be harmful to the sustainability of their operation are removed." (Price Waterhouse 1994, 36) The authors of this report believe that good farming practices are encouraged by individualized crop insurance which in turn leads to practices that are less harmful to the environment. This conclusion is based on a review of nine identified environmental issues and how crop insurance could impact on each of them. These issues include crop selection, land stewardship practices, input use, crop rotations, marginal land, farming practices, summerfallow, wildlife habitat, and organic production. A delivering agency of a public risk program is concerned with future losses that may be incurred due to this risk category. The public administrator would look at the effect on future income streams and the increased cost to the public risk program as a result of producers' environmentally harmful practices.

Global political risk is another risk that producers must "manage" within their

production decision making. The General Agreement on Trade and Tariffs is an attempt to cushion the potential negative impact of this risk.

2.2.5 Human Sources of Risk

Another risk the producer faces is the potential for making improper management decisions. For those producers who farm the land these risks typically relate to the use of improper cropping practices, including crop rotations, crops selected for planting, date of seeding, dates selected to harvest, and the spraying techniques used to control weeds and increase yields. Within the crop insurance context, deductibles and the application of uninsured causes of loss are used as ways of penalizing the producer for losses due to improper management practices.

The common denominator in all these events within the various risk groupings is the fact that producers who do not manage their risks will suffer harm or economic losses. Similarly, public programs that are designed to assist the producer in managing risk will also suffer unnecessary economic loss if programs indemnify producers for risks that they failed to manage properly. Given the array of potential risks faced by producers, and a limited public purse, administrators of public programs need to carefully evaluate which risks the public should be called upon to backstop. Some risk groupings are quantifiable while others are not. For the purposes of this study the sources of risk under consideration are "production", "market or price", "legal and social" and "human" risks. In the following section various models and risk measurement techniques are discussed, with the intention of applying them to the public risk programs discussed in the third section of this paper.

2.3 Risk Measurement

2.3.1 Statistical Measurement Tools

Prior to looking at specific risk models, a discussion of statistical measurements such as mean, variance and standard deviation is useful. The mean is a measure of central tendency and is simply the average of the sample data. Variance is a measure of dispersion for a data set, found by summing the squared deviations of the data values about the mean and then dividing this total by the number of observations (i.e., N) if the data set represents the population, or by $N-1$ if the data set represents a sample drawn from the population. Specific formulae for population mean and variance are as follows:

Population Mean

$$\mu_x = \frac{\sum_{i=1}^N x_i}{N} \quad (1)$$

Population Variance

$$\sigma_x^2 = \frac{\sum_{i=1}^N (x_i - \mu_x)^2}{N} \quad (2)$$

Where μ_x is the mean of x , σ_x^2 is the variance of x , x_i is the i^{th} observation and N is the number of observations.

The standard deviation (σ_x) is also a measure of data variation. Specifically, it is defined as the square root of the variance, and can be expressed as follows:

Population Standard Deviation

$$\sigma_x = \sqrt{\sigma_x^2} \quad (3)$$

A simple numerical example may be used to demonstrate the calculations. Table 1 provides a data set consisting of five observations.

TABLE 1 SAMPLE DATA SET

Event (i)	Value (x_i)	Squared Value (X_i^2)	Deviation from Mean ($x_i - \mu_x$)	Squared Deviation ($x_i - \mu_x$) ²
1	1	1	0	0
2	0	0	-1	1
3	-1	1	-2	4
4	2	4	1	1
5	3	9	2	4
N = 5	Total = 5	Total = 15	Total = 0	Total = 10

Substituting these values into the formulae (i.e., 1,2 and 3), the mean is calculated to be equal to 1 (5/5), the population variance is equal to 2 (10/5) and the standard deviation for the population is equal to 1.41. If the data set represents a sample, the sample variance would be calculated to be equal to 2.5 (i.e., dividing the sum of squared deviations by 4 instead of 5) and the standard deviation for the sample would be 1.58. The change in the sample variance and standard deviation is because one degree of

freedom has been used, symbolized by the use of $N - 1$ in the denominator.

One further formula that is relevant to the discussion of risk models is the covariance, which is expressed as follows:

Covariance

$$COV(x_i, y_i) = \sigma_{x, y} = \frac{\sum_{i=1}^N (x_i - \mu_x) (y_i - \mu_y)}{n - 1} \quad (4)$$

Where $COV(x_i, y_i)$ is the covariance between random variables x and y , μ_x and μ_y represent the means for x and y , respectively, and n is the sample size. If the data represents the population rather than a sample, the denominator is n , not $n-1$.

Assuming that the data sets for both X and Y are identical to the earlier example, and represent populations rather than samples, the covariance would be calculated to be 2 since the data sets are perfectly correlated. If there is no linear association between X and Y , their covariance would be 0.

Typically, data sets are not perfectly correlated. An alternative, but consistent, method of measuring the degree of covariance or correlation is the correlation coefficient. The correlation coefficient is obtained by dividing the covariance by the product of the individual standard deviations, and is expressed as follows:

Correlation Coefficient

$$Corr(x_i, y_i) = P_{x, y} = \frac{COV(x_i, y_i)}{\sigma_x \sigma_y} \quad (5)$$

Where $\text{Corr}(x_i, y_i)$ is the correlation coefficient and all other variables are defined as before.

A correlation of -1 implies a perfect negative linear association, +1 implies perfect positive linear association, while a value of zero implies no linear association. With the statistical review completed, a review of risk measurement techniques is now provided.

2.3.2 Portfolio Model

In 1959 Markowitz published the portfolio selection model that identified the set of efficient stock portfolios from all the available securities within the marketplace. He "proposed that decision makers select a portfolio based on a decision rule that minimizes the variance of profit for a given level of expected profit. When the level of expected profit is varied, this approach yields an efficiency frontier where variance is the measure of risk." (Selley 1984, 58)

This model can be described through the use of a two asset portfolio. The expected return on the portfolio, denoted $E(r)$, requires information concerning the relative "weight" for each investment; that is, the proportion of the total portfolio value attributable to each investment. These weights are then multiplied by the respective expected returns for each individual investment. Once this calculation has been determined the individual products are summed to provide the expected return for the portfolio. The expected return on a two asset portfolio is given by:

$$E(r) = a_1E(r_1) + a_2E(r_2) \quad (6)$$

Where a_i and $E(r_i)$ are the weight and expected return, respectively, for investment or asset I.

Suppose that a two asset portfolio has \$50 in investment 1 and \$50 in investment 2. The expected return for investment 1 is 1% and the expected return for investment 2 is 10%. Substituting these values into equation 6 results in a expected return for the portfolio of 5.5% [(.5*1%) + (.5 * 10%)].

The variance of a two asset portfolio is:

$$VAR(r) = a_1^2 \sigma_1^2 + a_2^2 \sigma_2^2 + 2a_1 a_2 \sigma_1 \sigma_2 \rho_{1,2} = a_1^2 \sigma_1^2 + a_2^2 \sigma_2^2 + 2a_1 a_2 \sigma_1 \sigma_2 \rho_{1,2} \quad (7)$$

Where VAR(r) is the variance of the portfolio, a_i is the "weight" for asset i, σ_i^2 and σ_i are the variance, and standard deviation of returns respectively, for asset i, and $\rho_{1,2}$ is the correlation coefficient for assets 1 and 2.

The portfolio model can be generalized to include any number of assets. The general formula for expected returns and variance of a portfolio are:

$$E(r) = \sum_{i=1}^n a_i E(r_i) \quad (8)$$

$$VAR(r) = \sum_{i=1}^n a_i^2 \sigma_i^2 + 2 \sum_{m < i}^m \sum_{i=1}^n a_m a_i \rho_{m,i} \sigma_m \sigma_i \quad (9)$$

where all variables are defined as before. Equation 9 indicates that the variance of returns faced by the investor is affected by the number of assets held (n), the variance of each asset (σ_i^2), the proportion invested in each asset (a_i) and the correlation of returns between assets ($\rho_{m,i}$). The portfolio model suggests that, under certain circumstances,

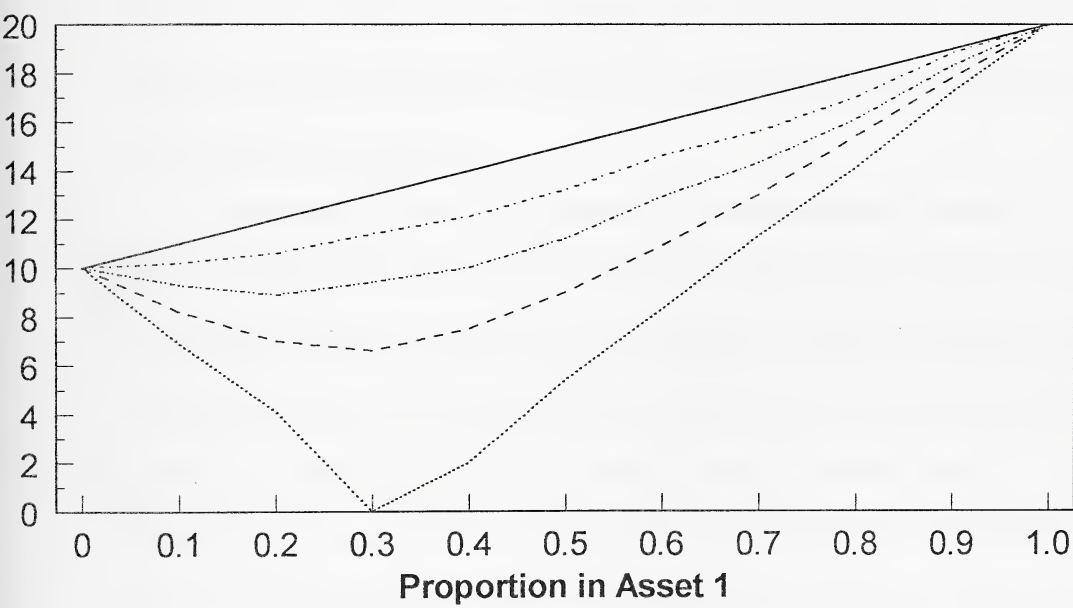
diversification in investments can lead to reduced risk. The risk reduction benefits from diversification improve as the correlation between assets becomes less positive. This is illustrated in Figure 1, in which the standard deviation for a two asset portfolio is graphed, assuming different combinations of the two assets and different correlation coefficients. In this graph the standard deviations of returns for assets 1 and 2 are 20 and 10, respectively. The benefits from diversification can be identified by considering the minimum attainable standard deviations for each correlation level. With correlations of 1 and 0.5, the lowest standard deviation is 10, produced by investing entirely in asset 2. A correlation coefficient of 0 produces a minimum standard deviation of 8.94, and a correlation of -0.5 results in a standard deviation of 6.56. A correlation of -1 produces a minimum standard deviation of 0, which implies the existence of a risk-free portfolio.

Clearly, diversification strategies should seek out investment options which demonstrate these lower correlations in an effort to reduce variability. In general, diversification among assets will reduce the minimum attainable variance if the correlation coefficient is less than the ratio of the smaller standard deviation to the larger one. It should also be remembered that diversification strategies may have additional fixed and variable costs which must also be considered within the context of overall risk management.

Figure 1

Standard Deviation for a Two Asset Portfolio with Varying Asset Proportions and Correlations ^a

Portfolio Standard Deviation



Corr = 1 Corr = .5 Corr = 0 Corr = -.5 Corr = -1

————— ····· - - - - - - · - · - ·····

^a The standard deviation of returns for assets 1 and 2 are assumed to be 20 and 10 respectively. "Corr" represents the correlation between assets 1 and 2.

From the previous two asset model, it may be implied that one risk reducing strategy is to minimize the variability of returns within a portfolio, for a given level of expected returns. This analysis also suggests that in the presence of two assets that are perfectly negatively correlated, a risk-free portfolio may be created. Unfortunately, in the real world this perfect negative correlation is rarely found, suggesting that there are limits to the risk reductions that can be achieved through diversification. It is further observed that there are common forces in the market that cause variability in both assets and other forces that cause exclusive or unique variability within the individual assets. The common forces also limit the potential for risk reduction through diversification and are discussed in more detail in the next section.

In summary, portfolio theory suggests that the effectiveness of diversification within a portfolio and thus the effective success in risk reduction can be measured through examination of correlation coefficients. This conclusion is a result of the application of the Markowitz formula which effectively takes each individual stock's covariance within the portfolio and weights them to produce a weighted average. The theory looks at diversifying investments so as to construct portfolios with higher expected returns and lower standard deviations. For a given investment fund this could mean a selected mix of treasury bills (safe investment) and common stocks (riskier investment).

2.3.3 Non-Systematic and Systematic Risk

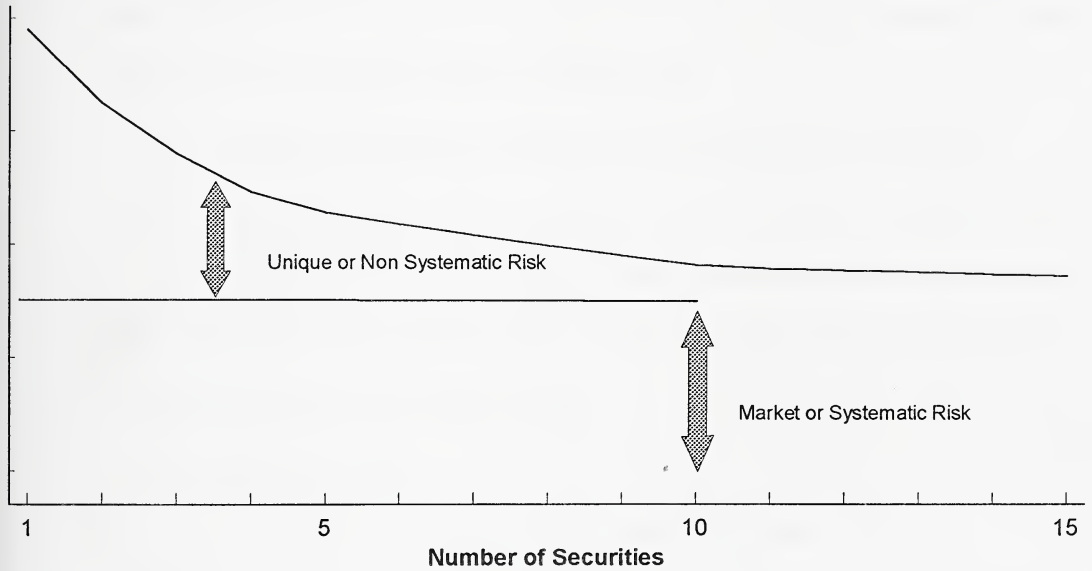
"The risk that can potentially be eliminated by diversification is called unique risk. This unique risk is also referred to as non-systematic, residual, specific or diversifiable risk. Unique risk stems from the fact that many of the perils that surround an individual

company are peculiar to that company and perhaps its immediate competitors." (Brealey et al 1992, 151) Systematic risk, on the other hand, is that risk which cannot be eliminated through diversification due to common variability among assets.

Systematic (market risk) and non-systematic (unique risk) risk may be described pictorially. Figure 2 illustrates the idea that as securities are added to the portfolio the non-systematic portion of risk for the portfolio is reduced while the market risk (i.e., systematic risk) remains constant as it cannot be diversified away.

Figure 2
Systematic and Non - Systematic Risk of a Portfolio

Portfolio Standard Deviation



Source: Brealey et al (1992)

The distinction made between non-systematic (unique) risk and the systematic (market) risk, as demonstrated in Figure 2 is an important one. The importance of this concept is twofold. First, an effective diversification strategy can reduce the unique risk and thus the cost of some public risk programs. Second, the systematic risk common to all farms is the risk which public programs should be designed to address in agriculture. This systematic risk is the risk that cannot be easily "managed" by producers on their own. Cost estimates of these public programs and some key program management issues can be evaluated using the concept of systematic risk.

Holders of portfolios are concerned with systematic risk. Indeed, the applications described in the following section will make use of this concept extensively. It is therefore important to have convenient methods for calculating and evaluating these risks. The Single-Index Model provides a convenient measure for systematic risk and will be discussed in the subsequent section.

2.3.4 Single-Index Model

In 1963 William Sharpe simplified the Markowitz model. The Sharpe methodology calculates the level of risk for each asset in a portfolio. This methodology can easily be adapted for other purposes such as those considered in the third section of this document. The model incorporates two underlying assumptions. First, each asset's return, r_j is linearly related to some common factor, r_m . In investment analysis, this common factor is often assumed to be a macroeconomic index. The second assumption is that the returns for different assets are related only by their relationship with this common factor.

The model may be mathematically described as follows:

$$r_j = \alpha_j + \beta_j r_m + \epsilon \quad (10)$$

Where r_j is the return for asset j , r_m is the common factor, α_j and β_j are the estimated coefficients specific to asset j and ϵ represents the random error term. The β_j coefficient measures the strength of the relationship between asset j and the common factor.

The variability of returns for each asset j can be shown as two distinct parts:

$$\sigma_j^2 = \beta_j^2 \sigma_m^2 + \sigma_{\epsilon_j}^2 \quad (11)$$

where $\beta_j^2 \sigma_m^2$ represents the non-diversifiable risk common to all assets, and $\sigma_{\epsilon_j}^2$ represents the individual asset's diversifiable risk.

Sharpe's model differs from Markowitz's model in that the Single Index model provides an estimate of the minimum variance. The Markowitz model provides, in theory, a perfect calculation of the minimum variance. The Sharpe model assumes "that the residuals for the different stocks are perfectly uncorrelated with each other." (Haugen 1986, 136) This assumption is founded on the premise that the individual stocks within the market are pushed or pulled in any one direction by a common inertia but that there are factors which cause unique variability for each firm. Should this assumption hold within the market place the single-index estimate will be accurate and the model will be useful in empirical analysis. It should also be noted that although this model refers to the return on an asset it could be used to depict other similar activities such as crop production yields.

Although the single-index model has been used in practice to determine the common stock mix within a portfolio and the Markowitz model has been used to determine the mix of investment instruments these models also have agricultural applications. Collins and Barry (1986) compare the expected value frontiers for the Markowitz and Sharpe Models for twelve crops commonly produced in Imperial County, California. The results of this comparison are reproduced in Figure 3 and Table 2. Figure 3 displays the efficient frontiers for the two alternative models. The Sharpe expected values closely parallel the Markowitz expected value frontiers. According to Collins and Barry, the maximum expected value for tomatoes is calculated to be identical at \$594.62 per acre under either model.

In Table 2, it may be seen that both models provide for an expected return of \$126.34 per acre with an increased risk level of 16.4 per cent under the single index model. This increased risk is due to the higher variability as demonstrated by a standard deviation of 33.5 for the Markowitz solution, and 39.0 for the single index solution. The study concludes that the "levels of accuracy for the single index method appear comparable to those achieved in other studies of stock portfolios. Moreover, consistent with Sharpe's findings, the single-index method achieves considerable computational efficiency by requiring only 16% of the processing time on the Rand quadratic program and 11% of the memory space required by the Markowitz method". (Collins and Barry 1986, 155). These results allow us to proceed to apply the single index model to various public risk programs in the following section.

Figure 3 **Markowitz and Sharpe Expected Value Frontiers**
 (Source: Collins and Barry, 1986, 155)

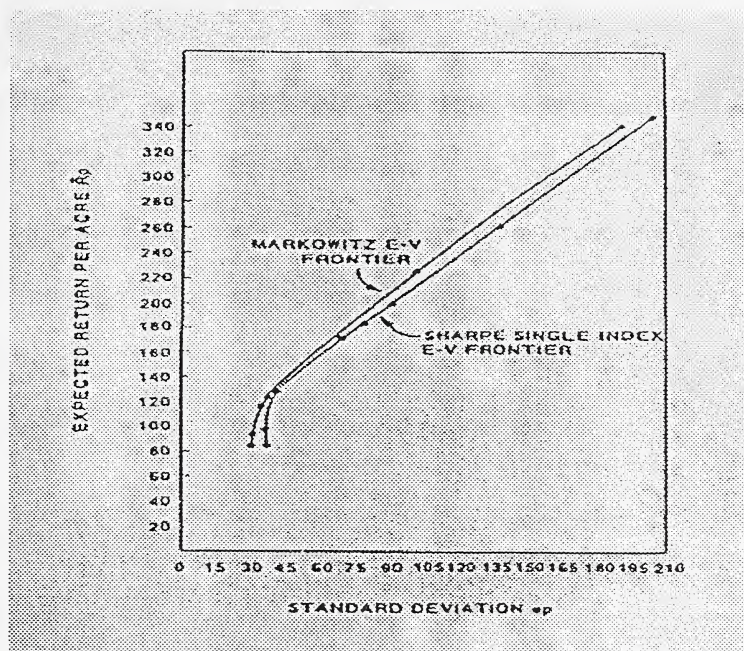


TABLE 2

Crop Proportions and Risk-Return Measures

Crop	Markowitz Solution	Single- Index Solution
Alfalfa	0.000	0.026
Sorghum	0.541	0.525
Sugar Beets	0.063	0.102
Asparagus	0.111	0.050
Cantaloupe	0.074	0.134
Carrots	0.000	0.000
Cucumbers	0.036	0.007
Lettuce	0.067	0.026
Onions	0.000	0.034
Tomatoes	0.038	0.042
Watermelon	0.012	0.008
	0.058	0.046
Variance	1123	1525
Standard Deviation	33.5	39.0
Expected Return	126.34	126.34

Section 3 Application to Public Risk Programs

The previous discussion provides a review of the basic concepts and tools associated with portfolio theory. That discussion addresses the topics of systematic and nonsystematic risk, which can be used to decompose the variability present in any particular portfolio. These concepts may be applied to any problem which has the characteristics of a portfolio, even if that problem does not superficially look like the standard financial market portfolio. One such case involves the development and administration of public risk programs in agriculture. The assets in this portfolio are the claims arising from the activities of individual businesses. The central agency is faced with the problem of managing those claims which are, by their very nature, uncertain. Thus, the agency has a portfolio management problem and can use the tools of portfolio theory to evaluate and manage those claims.

This section of the paper discusses three such portfolio problems facing providers of public risk programs. The first problem is that of crop insurance which is administered publicly and faces many problems such as rising costs, dropping participation, moral hazard and adverse selection. Portfolio theory and specifically the concept of systematic risk have been used to evaluate alternative insurance instruments which may be used to address these problems. The second application is related to crop insurance and deals with issues of risk management tools which may be available to insurance providers. The specific tool discussed here is the potential for area yield options instruments, traded on public markets, to be used to manage the yield risk accepted by insurance providers. Once again, portfolio theory can be used to evaluate and measure that potential. The third

and final application is to public revenue stabilization schemes currently being considered in Canada under the heading of companion risk programs.

As in the previous cases, these programs involve potential claims to the program provider, contingent upon uncertain income realizations from farming activities. The program administrators are concerned with evaluating the potential payments which they may be required to make to their clients. These claims represent a portfolio to be managed by program administrators. By understanding the characteristics of a portfolio, a reasonable estimate of future claims can be developed. The next section contains a brief description of crop insurance in Alberta followed by the first application, area yield insurance. The remaining sections consider area yield options and companion programs, respectively.

3.1 Alberta's "All Risk" Crop Insurance

The purpose of "all risk" crop insurance is to guarantee individual insured farmers a specific number of bushels of a designated quality grain, and to pay for losses when the harvested production falls below the guaranteed level. Coverage (i.e., the production guarantee) and premium rates are calculated for each insurable crop based on the actual long-term yield and loss experience for a designated area. These designated areas are referred to as "risk areas" and are defined so as to account for differences in climate, soil and other conditions which affect the production capabilities and loss probabilities.

Individualized crop insurance is provided through the calculation of an index or coverage adjustment for each producer based on their net production for each insured crop. The calculation is made by comparing the producer's net production to the net

production for the same crop within a risk area. The comparison, favourable or unfavourable, will determine the coverage for the following year. This index is important and represents risk to the insurer. Overstatements of reported yields will result in over coverage, and accordingly, increased costs to the corporation in the future. Finally, price options are the expected value of the insurable crop, and are what establishes the guarantee in a common measurement unit (i.e. , dollars).

Appendix A provides a set of sample calculations for a farmer in the 1993 crop year. For the All Risk Crop Insurance component of the worksheet, the coverage for red spring wheat crop is calculated by taking the area normal yield of 46.3 bushels, multiplying it by an index of 1.0, multiplying that by a 70 per cent coverage level, and finally multiplying that by a price option of \$2.99. The product of the previous numbers yields a coverage of \$96.91 per acre. With the producer premium rate set at 3.6 per cent the cost to the farmer would be \$3.49 per acre insured. The calculations for barley follow the same methodology.

Two important calculations within the sample worksheet are the area normal and the coverage adjustment or index. The area normal represents the ten year average for every insurable crop within a given risk area while the coverage adjustment represents the individual producer's historical production capability relative to the risk area. Table 3 provides a numerical example to demonstrate the calculations required in determining the annual producer's coverage adjustment.

TABLE 3
Selected Crop Insurance Coverage Adjustment Calculations
For the Six Crop Years Ended 1992 (in Bushels)

Year	Area Normal (1)	Farmer's Yield (2)	Area Average Yield (3)	Farmer's Adjusted Yield (4)	Area Ave. Adj. Yield (5)	Cumula- tive Index (6)	Coverage Adjust- ment (7)
1987	27	32	28	32	29	1.1	1.05
1988	27	35	25	35	26	1.22	1.1
1989	28	30	27	30	27	1.18	1.15
1990	28	17	15	17	15	1.18	1.18
1991	27	33	31	33	32	1.14	1.14
1992	27	12	26	21	27	1.08	1.09
1993	27	n/a	n/a	n/a	n/a	n/a	n/a

Source: Agriculture Financial Services Corporation

Explanations for each column are as follows:

- (1) Area Normal is the ten year average production for producer's in a given risk area.
- (2) The farmer's yield is an individual producer's production for a given crop year.
- (3) Area average yield is the annual production average for producer's in a given risk area.
- (4) The farmer's adjusted yield for 1992 is calculated as 21 bushels. The coverage level (.70), times the area average yield (26.0), times the coverage adjustment for the previous year (1.14).
- (5) The area average adjusted yield is commonly referred to by the corporation as "cushioning". This cushioning is intended to be a stabilizing formula and requires a recalculation of the area mean after upwardly adjusting the individual means of

those individual producer's who fall below 70 per cent within the risk area.

(6) The cumulative index is the summation of the farmer's adjusted yield divided by the area average adjusted yield (i.e. , for 1988 it would be calculated as $(32+35)/(29+26) = 1.22$). The corporation also places a ceiling and floor of 5 "index points" either up or down for the first four years (3 years for 1994 and thereafter) so as to cushion the individual producer from potentially unrepresentative years. For 1992 the calculation would be $1.08[(32+35+30+17+33+21)/(29+26+27+15+32+27)]$

(7) The coverage adjustment is multiplied by the area normal to determine current years coverage. In 1992, the coverage adjustment varies from the cumulative index even though the four years of production records have been attained, because the elimination of the 5 "index point" ceiling and floor provision is not fully implemented until 1996 (i.e. , $1.14 - 0.05=1.09$).

The crop insurance programs are cost-shared, and are directed by the Canada/Alberta Crop Insurance Agreements. Accordingly, they must comply with both federal and provincial legislation. Of the total crop insurance premium, 25 per cent is paid by the province, 25 per cent is paid by the federal government and 50 per cent is paid by the producer. Therefore any net gains or savings in program costs benefit all funding participants. The administration costs for the "all risk" crop insurance program is shared equally between the two levels of government.

Reviews of individualized crop insurance programs disclose two inherent weaknesses -- moral hazard and adverse selection. These weaknesses represent

additional risk for an insurance program that are difficult to quantify but present none the less. A brief discussion of these weaknesses is provided below:

3.1.1 Moral Hazard

When an individual is fully underwritten and cannot be accurately monitored by an insurance company the insureds behavior may change after the insurance has been purchased. This change of behavior is known as moral hazard. According to Pindyck and Rubinfeld "moral hazard occurs when the party to be insured can affect the probability or magnitude of the event that triggers payment". (Pindyck and Rubinfeld 1992, 620) Within crop insurance moral hazard can be described as maximizing program benefits through deliberate actions by the farmer. This could include actions such as reducing inputs (e.g. , fertilizer) or committing fraudulent acts (e.g. , falsifying records). In some situations, "moral hazard" means producers are deliberately cheating the program, while in other situations, participants bend rules beyond their initial intent. Josh Billings stated that: "there are lots of people who mistake their imagination for their memory."

Whatever interpretation one chooses to select, the result is the same. Producers are overpaid for damages incurred, and all participants are penalized by future increased premiums and/or reduced coverage levels. This may also cause a loss of credibility in the program and a lack of confidence in the corporation that markets the insurance products.

Emmett and Therese Vaughan make a further distinction by distinguishing between moral and morale hazard. They view moral hazard as "the increase in the probability of loss that results from dishonest tendencies in the character of the insured

person." (Vaughan and Vaughan 1995, 8) Morale hazard they consider to be "acts to increase losses where insurance exists, not necessarily because of dishonesty, but because of a different attitude toward losses that will be paid by insurance." (Vaughan and Vaughan 1995, 8) An example of this may be the insured has a more careless attitude toward losses since they will be covered by insurance.

3.1.2 Adverse Selection

Pindyck and Rubinfeld describe adverse selection as a condition where "high-risk individuals are more likely to buy insurance than low-risk individuals. If insurance companies must charge a single premium because they cannot distinguish among these individuals, it may become unprofitable to sell insurance. Similarly, if a single price is to be charged for indistinguishable low and high-quality products, high-quality products may not be sold." (Pindyck and Rubinfeld 1992, 683) This condition leads to an implicit subsidy of some groups of producers at the expense of others. Mehr and Gustavson similarly define adverse selection as "parties with loss probabilities significantly above those allowed for in the premium will purchase the insurance in order to take advantage of a condition adverse to the insurer." (Mehr and Gustavson 1987, 174)

Adverse selection within the context of crop insurance certainly includes the previous definitions. It also includes situations where a producer will make cropping decisions based on the support offered by the insurance program and not on the basis of market prices and conditions.

The moral hazard and adverse selection problems require that premiums be adjusted so as to maintain actuarial soundness. Unfortunately, quantifying the increased

insured risk due to moral hazard and adverse selection is a difficult if not an impossible task. Insurance programs that can be designed with reduced moral hazard, and with less adverse selection can be funded with reduced premiums and premiums that are more reflective of the true risks being insured for. This observation leads us to look at area-yield crop insurance which is described in the following section.

3.2 Area-Yield Crop Insurance

"The first use of area-yield crop insurance in Canada fell under the 1939 Prairie Farm Assistance Act (P.F.A.A.), which provided crop loss protection for Manitoba, Saskatchewan, Alberta and parts of British Columbia. Although it shared some of the features of a crop insurance plan it was actually considered a permanent disaster relief plan." (Turvy and Islam 1995, 25).

Area yield based insurance was proposed as an alternative to traditional crop insurance as early as 1949 (Halcrow 1949). The Halcrow Plan proposed to treat all participating producers within a geographic area in exactly the same manner. For a given area, a premium rate would be set, a predetermined production level to trigger an indemnity payment would be established, and an area average yield would be calculated. If the area average fell below the predetermined production level, an equivalent payment would be made to all participating producers in a given risk area. Presently the U.S. Federal Crop Insurance Corporation is conducting a pilot test of area yield in 30 soybean markets in 13 states across the eastern United States. (Skees et al 1993)

Potential advantages of an area based plan include simplicity, reduced administrative costs and lower premiums. The demonstration of these advantages is not

complex. Suppose that 20,000 producers participate in a given crop insurance program. Under the area based plan, there would be less stringent requirements for ensuring the accuracy of individual yields compared to an individualized plan. This is due to the fact that individual producers cannot alter the payouts received by, for example, misreporting production results. In Canada as much as 40% of public agency administrative budgets have been consumed by detailed verification, and adjusting procedures to mitigate this human source of risk.

The advantages cited for area-yield crop insurance are: "area-yield crop insurance, may provide more effective yield-loss coverage than individually tailored insurance, without most of the adverse selection and moral hazard problems that have historically undermined the actuarial performance of the federal crop insurance program." (Miranda 1991, 233) But do adverse selection and moral hazard really exist within the current system? Is there justification for the expensive verification and adjusting processes presently operating in many jurisdictions in Canada?

As discussed in section 3.1, Alberta's individualized crop insurance calculates an index or coverage adjustment for each policyholder. This calculation affects the premium that the producer will pay, the amount of coverage the producer will receive, and ultimately the amount of indemnity received in a loss situation. Therefore, an important difference between area-yield and individualized crop insurance is the potential for an individualized plan to create an incentive for producers to alter their production results, as it will affect the payment(s) received.

To determine the extent to which producer misreporting existed within Alberta,

Agriculture Financial Services Corporation conducted a project, coordinated by Lou Zhijian. The objective of the project was to compare actual yields measured by adjusters and declared yields filed by the insured producers. The availability of both measured and reported yield data for the period from 1991 - 1993 provided the basis for the review. The results of this project suggested that if policyholders were close to being in a claim position they were more likely to understate production in order to receive a higher indemnity payment. Producers not in a claim position were more likely to overstate their production so as to maximize future economic benefits by increasing individual indexes. Further details of this project are included in Appendix B of this report.

Given that moral hazard appears to be occurring within Alberta's current crop insurance program, a closer look at Miranda's proposed area-yield crop insurance is warranted. This model if proven to be practical for Alberta would also be very attractive since it could be more cost effective. The mathematical representation of Miranda's model is as follows:

$$\bar{y}_i = \bar{\mu}_i + \beta_i (\bar{y} - \mu) + \bar{\epsilon}_i \quad (12)$$

where,

$\bar{y}_i$ represents the i^{th} producers yield,

$\bar{y}$ represents the area yield,

$\bar{\mu}_i$ represents the i^{th} producer's average yield

$\bar{\mu}$ represents the area average yield

$\bar{\epsilon}_i$ represents the non-systematic component that is uncorrelated with the area yield.

The first observation that can be made about the model is that it is similar in appearance to the single index model presented in equation 10. The single index model and the concept of systematic risk are used by Miranda to describe the relevant portfolio problem. The expression provided by equation 12 evaluates an individual farmer's yield in terms of its relationship with those of others in the area, and incorporates both systematic and non-systematic risks. The term $\beta_i (\bar{y} - \mu)$ measures the sensitivity of the producer's individual yield to systematic factors (e.g. ,weather) which would affect the area yield. These systematic factors are those which should be addressed by an insurance program. The greater the value of β_i , the greater the effectiveness of the area yield insurance program in managing risk. The ϵ_i term measures the non-systematic risk. The non-systematic risk may be mitigated by management decisions such as carefully planned diversification plan by the individual producer.

The yield risk facing the i^{th} individual can be redefined from equation 12 to be:

$$\sigma_{\bar{y}_i}^2 = \beta_i^2 \sigma_{\bar{y}}^2 + \sigma_{\bar{\epsilon}_i}^2 \quad (13)$$

where,

$\sigma_{\bar{y}_i}^2$ represents the variance of the i^{th} producer's production,

$\beta_i^2 \sigma_y^2$ represents the systematic risk

$\sigma_{\epsilon_i}^2$ represents the non-systematic yield risk.

As mentioned above, area yield insurance is designed to address the systematic component of yield risk. Evaluation of area yield insurance in terms of its ability to mitigate yield risk and its potential cost to producers is dependent on the degree of total risk that is in nature. Miranda (1991) tested his model on 102 soybean producers from Kentucky. The results of this review show that the beta range is normally distributed. A critical beta is determined when it is noted that the weighted average of the beta within a given area always equals one. The critical beta represents the point where, if production falls below this level, an indemnity payment would be triggered.

Examples of the critical beta, per-acre premium, and average optimal coverage under an area yield plan for a selected range of values illustrate this relationship. At 60 per cent of normal the bushels per acre are 18.4 with a critical beta of 0, and a premium of 0. This would be the expected result since at this level of coverage area-yield insurance is completely ineffective (i.e., the probability of production falling below 18.4 bushels for the area is very low). At 90 per cent of normal, 27.7 bushels per acre, a critical beta of 0.28, a premium of 0.96 bushels per acre and optimal coverage of 178 per cent are observed. At the 125 per cent of normal coverage, we see values of 38.94 bushels, a

critical beta of 0.5, a premium of 7.69 bushels per acre and 100 per cent as the optimal coverage level.

So what does all this mean? As the critical beta and percentage of normal increased the area-yield insurance became more risk reducing when compared to no insurance coverage. Comparing the results of the individual plan to the full coverage area plan and the optimal coverage area plan as summarized in Miranda we saw that on average area insurance premiums were much lower than individual yield insurance premiums.

Turvey and Islam (1995) also address area yield insurance. They state that "in terms of efficiency in risk-reduction individual plans are superior to area plans. As it turns out arguments of asymmetric information which has led some researchers to investigate area versus individual yield insurance is not totally resolved" (Turvey and Islam 1995, 23).

Some of the specific results reported by Turvey and Islam are "the differences in premiums across counties for like crops can be substantial, and second, individual premiums, on average, are substantially higher than area premiums. For example, 85% area coverage premiums for corn range from \$1.58/acre in Kent county (western Ontario) to \$10.86/acre in Russel county (Eastern Ontario), whereas 85% individual coverage premiums for corn range from \$7.15/acre in Kent county (western Ontario) to \$20.91/acre in Prescott county (central Ontario). The following differences between area and individual premiums are notable: 85% coverage area premiums for soybeans in Perth county are only \$0.51/acre whereas 85% coverage individual premiums are 7.3 times as

high, ie. \$3.75/acre; similarly, soybeans in Middlesex county are barely priced by area yield insurance even at the 85% level (\$0.07/acre) but are \$4.08/acre on an individual yield plan. Of the 25 crops/county representations 100% had average individual yield premiums higher than area-yield premiums and 60% had individual premiums which are at least twice as high as area premiums " (Turvey and Islam 1995, 31)

3.2.1 Empirical Illustration of Area Yield Insurance

A brief numerical example of the calculations illustrates an area yield program for Alberta. The area selected is the County of Lacombe (map area 25) for ten crop years ending in 1993. The crop used in this example is canola and the sample includes all producers who have 8 years of yield records. This selection criterion results in a sample of 25 producers from an eligible population of approximately 2000 farmers. For each farmer indicated by an alphabetic letter the corresponding individual index for the individualized crop insurance program is also provided. The individual index represents the production capability of a given producer. For example, farmer A has an individual index of 1.07 and is denoted A-1.07. The individual yields along with the area average for both the sample and population groups is reproduced in Table 4.

Individual betas for each of the 25 producers are estimated using an ordinary least squares regression of the area average yields on the individual yields of each producer. This is the same approach used by Miranda (i.e., equation 12). The results are provided in Table 5.

Table 4
Selected Canola Production Statistics for Individual Producers
in the County of Lacombe, 1986-1993 (Bushels/acre)

<u>Farmer</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>
A-1.07	25.18	30	24.01	25.88	25.04	28.35	21.71	19.09
B-1.26	30	20	25	32	30.02	19.63	37.13	28.82
C-1.00	30	25	21	25	16.97	0	0	22.54
D-1.05	35	28	7.98	20	14.99	0	0	39.64
E-1.05	30	20	25	23	20.06	26.99	16.23	25.81
F-0.96	35	25	20	22	32.01	23.02	16.06	25.82
G-1.01	35	35	24	22	23.01	21.11	24.05	23.2
H-0.99	25.74	33	30	30	30.05	16.81	18.55	27.61
I-1.04	16	28	35	25	31.04	24.45	7.85	26.36
J-0.79	25.93	30	22	22	15.82	11.85	19.32	7
K-0.84	30	16.97	32.68	15	22.48	12.9	19.73	17.17
L-0.80	20	22	22	15	22	21.91	13.32	20.6
M-1.21	35	30	23	30	18.38	24.81	30.42	32.69
N-1.20	25.82	25	22.64	10.96	22	21.57	20.46	35.72
O-1.08	30	30	27	30	30.02	19.65	25.15	28.25
P-1.22	32	16	22	30	23.01	24.76	28.16	27.02
Q-1.06	22.48	21	26	23.47	19.83	20.96	22.55	23.25
R-1.29	0	22	21	20	26	21.16	32.58	35.43
S-1.31	0	30	22	26	25.26	30.98	31.76	29.23
T-1.22	35	30	23	25	30.02	26.29	27.55	26.66
U-1.17	22	33	20	30	19.09	21.43	32.51	25.23
V-0.76	16	28	27.62	10.85	31.04	20.48	11.4	13.88
W-1.29	25	27	27	25	35	22.47	42.48	29.64
X- 1.15	32	32	32	28	31.04	20.11	27.23	28.82
Y- 1.21	25	23	18	28	25.04	25.6	25.74	31.21
Area -S *	25.96	26.53	23.27	23.12	24.56	20.42	20.89	25.96
Yield-P	23.17	24.09	23.94	21.13	23.73	22.1	22.28	27.422

* The Area-S and Yield-P refer to the area yield for the sample and the area yield for the population.

Table 5

Beta Estimates for Area Yield Model, Selected Producers in Lacombe County

Farmer	Beta	$\beta_i > .5$	$\beta_i \leq 0$	$0 \leq \beta_i \leq .5$
A-1.07	-0.931		x	
B-1.26	-0.466		x	
C-1.00	1.951	x		
D-1.05	4.839	x		
E-1.05	0.391			x
F-0.96	0.789	x		
G-1.01	0.327			x
H-0.99	1.011	x		
I-1.04	1.471	x		
J-0.79	-1.579		x	
K-0.84	0.471			x
L-0.80	0.869	x		
M-1.21	0.386			x
N-1.20	3.29	x		
O-1.08	0.467			x
P-1.22	-0.655		x	
Q-1.06	0.11			x
R-1.29	2.119	x		
S-1.31	0.301			x
T-1.22	0.073			x
U-1.17	-0.506		x	
V-0.76	0.749	x		
W-1.29	0.211			x
X- 1.15	0.737	x		
Y- 1.21	0.453			x

* Betas are obtained by regressing area average yields on yields for individual producers (i.e. , equation 12)

Of the 25 producers, 10 have betas that are greater than 0.5. These producers should find area-yield insurance to be risk reducing due to the strong correlation between individual and area yields. A further five producers have betas that are less than 0. Area yield insurance is likely risk augmenting to this group (i.e., a negative correlation between individual and area yields). The remaining 10 producers in the sample group have betas between 0 and 0.5 and may or may not find area-yield insurance to be risk reducing. According to Miranda this would depend on the critical yield level, y_c . Higher critical yields make it more likely that area -yield insurance will be risk reducing. It should be remembered that the sample used in this example is small, and canola is a higher risk crop than other grains and oilseeds. Finally only a limited review of the data is made. Given the results obtained with these data, it appears that this study should be expanded to other risk areas and to other crops prior to making any recommendations as to the adoption or rejection of area-yield crop insurance for Alberta.

Reflecting upon the results of the review on area-yield insurance, it may be concluded that area yield insurance is really a form of a hedging instrument. Brealey et al state that “some risks can be hedged (ie. offset) by trading in options, futures, or other financial instruments.” (Brealey et al 1992, 663) Area yield insurance is simply another financial instrument that can be used to offset a producer’s production risk. The next section examines futures and option contracts as public risk programs to see if the single index model continues to have application.

3.3

Area-Yield Options

The introduction of this paper provides a quote from Adam Smith, describing insurance in terms of pooling risks and sharing them amongst all of society. Within conventional insurance this concept works well since losses within the group tend to be independent and the distribution symmetrical. This means within the conventional house insurance market for example, that not everyone's house burns down at the same time. Crop insurance claims on the other hand, are not independent but tend to be highly correlated geographically. This is one reason Miranda and Glauber (1995) propose that individualized crop insurance is ineffective. The authors assert that "private crop insurance markets fail primarily because systemic weather shocks induce significant correlation among farm-level yields, defeating insurer efforts to pool crop loss risk across farms." (Miranda and Glauber 1995)

Miranda and Glauber (1995) use the single index model to measure the relationships among yields across areas and crops in order to test their assertions. The use of this model allows the authors to isolate the systematic risk from the non-systematic risks. The study uses selected samples of individual yield records from more than 90,000 producers of corn, soybean and wheat for the eight year period from 1985 to 1992. In addition area based data for these crops are used for the thirty year period from 1963 to 1992. For the aforementioned data "each single index model was estimated by regressing the detrended farm-level yields against the corresponding county's detrended yields for 1985-92 using Ordinary Least Squares. The single index models were then used to generate cross-sections of detrended farm-level yields for 1963-92, the period for

which county yields were available. This was accomplished by conditioning on the detrended county-level yield and simulating a farm-level residual yield shock for each farm and year."(Miranda and Glauber 1995, 6)

These data are presumed to be representative for yield distributions of crop insurance program participants in 1992, the baseline year. From these data, indemnity payments for individual producers are calculated at the state and crop level, for all 30 years of the empirical yield distribution.

As Miranda and Glauber (1995) show, the measure of the systematic risk within the insurer's portfolio can be calculated by the covariance ratio. When the ratio equals one risks are considered to be independent. If the ratio is greater than one, the risks are systematically correlated. The results of this review suggest that crop insurers face a great deal of systematic risk. After isolating the systematic and non-systematic risk within the crop insurer's portfolio it is found that the risks are about ten times larger for crop insurers than for other insurers offering more conventional lines of insurance.

The issue for the public administrator(s) is how to "manage" this systematic crop loss risk? In Canada the answer has been re-insurance. Vaughan and Vaughan define reinsurance as "insurance for insurers." (Vaughan and Vaughan 1995, 121) Reinsurance is a way for an insurer to reduce the amount of risk within a given portfolio. However, financial difficulties place pressure on public administrators to search for other alternatives. For example, in Saskatchewan the reinsurance fund experienced a fund deficiency of \$160,212,309 for the year ended March 31, 1993. (Saskatchewan Crop Insurance Corporation 1993)

A third alternative to managing systematic agricultural risk is discovered when one considers that market structures already exist that are designed expressly to handle systemic risk -- options and futures markets. The values of options and futures contracts, such as those traded on the exchange markets in the United States and Canada, are typically based on the price of a commodity or stock or on a broad index of stock prices or interest rates. In theory, it would be possible to design an area yield options contract to manage the systematic risk facing crop insurers. The basic design features of such a contract would be that the value of the contract would have to rise and fall inversely with changes in expected aggregate crop yields.

Although crop yields tend to be correlated across farms, the relationship is not perfect. The correlation between area and individual yields is probably insufficient for options based on total yield short falls to offer adequate protection to individual producers. Therefore, neither insurance markets nor option markets can provide sufficient crop loss risk protection in the absence of substantial cash reserves or independent financial support. As an alternative to governments being required to pay the bill, the simultaneous operation of insurance and options markets could equip producers and public risk program administrators with a market solution to this crop risk insurability problem.

To manage systematic crop loss risk, Miranda and Glauber (1995) propose exchange-traded area-yield options contracts. Area-yield options could be designed to offer protection against regional yield shortfalls, allowing crop insurers to hedge their contract portfolios against calamitous losses arising from widespread natural disasters.

Miranda and Glauber (1995) also address the issue of effectiveness for area-yield options. To examine this issue, a simulation model is employed to compute the variability of insurance company portfolios under the assumption that the portfolios are reinsured or optimally hedged against area-yield contracts. The results show that the government reinsurance agreement reduces the variability of insurance company portfolios between 26 and 35 per cent of expected indemnities. The most dramatic risk reduction is obtained when area-yield options contracts are offered for every state. More importantly, however, state area-yield options would allow crop insurers to reduce their portfolio risk to levels comparable to those enjoyed by conventional insurers.

Area-yield options contracts offer numerous other advantages over the government subsidized reinsurance program. For example, area-yield options contracts would be efficiently priced on a competitive market and would offer open public discovery of aggregate yield expectations.

One final benefit from area-yield options is that they would be available to all industries or sectors whose income or welfare depend on aggregate agricultural production. Finally, “many questions remain regarding the optimal design of area-yield options. First, the crops or crop groups and the states or regions for which contracts are to be offered must be selected. The greater the number of crops and regions for which contracts are offered, the more effective the hedges that can be constructed by insurers. However, more contracts imply thinner markets and less liquidity per contract, potentially undermining the trading of the contract on organized exchanges. Other issues include what the specific settlement provisions for area-yield contracts should be. In particular,

the timeliness and security of USDA final crop yield estimates become critical to the design.”(Miranda and Glauber 1995, 15)

One final caution is that within Canada there presently does not exist options and futures markets to provide the hedging instrument that has been previously discussed. A review of existing Canadian markets for suitability and/or the creation of new Canadian markets may be helpful to see if this proposed area-yield option could have application in Canada.

The previous sub-sections have examined “All Risk Crop Insurance”, area-yield crop insurance, and area-yield options. These alternatives have been modelled as applications of systematic and nonsystematic risk. A common theme is the need to manage the systematic versus nonsystematic risk in public risk programs and the ability to measure these risk components through the use of the single index model. At the same time the examples are focused on the production risks in the grain and oilseeds sector of the farm enterprise. An interesting question is whether these observations would hold in other farm sectors and for variables such as income. Recently, administrators of public risk programs in Canada have recognized that companion stabilization programs, combined with national programs, are required to maintain equity of program supports and insurance at the provincial level and amongst the various farm sectors (i.e., grain producers versus cattle producers).

The next section provides an examination of the Farm Income Stability Program (FISP)--the companion program proposed for Alberta. This program can be assessed in terms of two important concepts: the magnitude in risk reduction effectiveness of a public

risk program can be measured by the correlation coefficient with higher expected returns and lower standard deviations indicating lower variability (an objective of the companion program); and the distinction between non-systematic and systematic risk. The systematic risk component can aid the public administrator in directing scarce funds towards those variations in income caused by systematic risks that are not able to be managed by the producers. Recognizing that FISP is just another portfolio problem with only the key variable changing (from net production to gross margin) the application seems certain. By understanding the characteristics of the FISP portfolio, a reasonable estimate of future claims can be developed. Once again it may be seen that the application of the tools of portfolio theory can be used to evaluate and manage the FISP claims.

3.4 Companion Stabilization Programs

The Farm Income Stabilization Program is designed to work in conjunction with the Net Income Stabilization Account program (NISA) and existing crop insurance programs in Alberta. The basic concept of the program is that a three year moving average of income, as reported on Revenue Canada's Statement of Farming Activities T2042 form, is calculated for the farmer. This is referred to as the reference margin. If income in a particular year falls below 70 per cent of the reference margin (less program specific adjustments), the farmer is eligible for assistance from this program. Any producer who feels that a payout is warranted based on this program criterion is required to make application on or before July 31st of the subsequent calendar year. Further details of the program are included in Appendix C. A simple example can be used to illustrate the mechanics of the program. The data in Table 6 are used in this example.

Table 6
Sample Four Year Income Data Set
For the Four Crop Years Ended 19X4
(Dollars)

Year	Program Revenue	Program Expense	Program Margin	Reference Margin
1	2000	1000	1000	-----
2	1900	950	950	-----
3	2100	1050	1050	1000
4	1000	1100	50	

The calculation for the program payment in year four, with selected program specific adjustments, are provided in Table 7:

Table 7
F.I.S.P. Calculations for Year 4 of the Sample Data Set
For the Four Crop Years Ended 19X4
(Dollars)

Description	Amount
Net income (loss) before program adjustments	-100
Add: Accrual adjustments:	
Ending Inventory	10
Trade receivables	90
Expenses excluded for F.I.S.P. program margin:	
Capital Cost Allowance	80
Sub-Total	80
Deduct: Opening Inventory	10
Other income - ie. pasture rent	5
Trade Payables	15
Current Year F.I.S.P. Margin	50
The calculation of the Farm Income Stability Program in year four would be:	
70% of the reference margin (70% X 1000)	700
Less: Current year F.I.S.P. Margin	50
Farm Income Stabilization Program payment for year four	650

Certain conditions apply for FISP. Any payments from crop insurance claims are considered income, and government money accumulated in NISA (commencing in the 1996 taxation year) must be deducted before any payments will be made from FISP based on 19X5. In addition an application fee of \$50 is required at the time that an individual producer makes a claim with a further 1 percent of the total payment being withheld to a maximum of \$500. In this example the producer would pay a total of \$56.50 (\$50 application fee and \$6.50 administration fee).

Certain measures are taken in an effort to protect the integrity of crop insurance and to maintain the producers' incentives to purchase crop insurance. FISP does not pay for negative margins, FISP payments are excluded in the calculation of the reference margins and negative margins are included in the calculation of reference margins. Finally, payment caps are provided so as to place a maximum limit on the total funds that can be expended in a given year.

The Farm Income Stabilization Program, as with the programs discussed previously, involves potential claims to the program provider contingent upon uncertain income realizations from farming activities. As before, the program administrators are concerned with evaluating the potential payments which they may be required to make to their clients. These are claims which represent a portfolio to be managed by the administrators. By understanding the characteristics of the FISP portfolio, a reasonable estimate of future claims can be developed. Once again, the application of the tools of portfolio theory can be used to evaluate and manage the FISP claims.

The single index model and the notion of systematic risk describe the relevant portfolio problem for FISP. Using (12), an individual farmer's income or gross margin

can be described in terms of its relationship with the income or gross margins for other producers in the province. The term $\beta_i (\bar{y} - \mu)$, can be used to measure the sensitivity of the producer's individual gross margin to systematic factors such as prices and weather which affect gross margins for the province. These systematic factors are those which should be addressed by the companion program. The ϵ_i term measures non-systematic risk. Non-systematic risk can be mitigated by management decisions such as carefully planned diversification plan by the individual producer.

The income risk facing the individual can be redefined from (12) to be:

$$\sigma_{\bar{y}_i}^2 = \beta_i^2 \sigma_{\bar{y}}^2 + \sigma_{\epsilon_i}^2 \quad (14)$$

where,

$\sigma_{\bar{y}_i}^2$ represents the variance of the i^{th} producers mean income

$\sigma_{\epsilon_i}^2$ represents the non-systematic risk associated with the i^{th} producer

$\beta_i^2 \sigma_{\bar{y}}^2$ represents the systematic risk associated with the i^{th} producer

Comparing (13) and (14), it can be seen that they are identical excepting the variable income has been inserted in place of mean production. This single index methodology can once again be used to measure the relationships among incomes across a selected geographic area for the various participating commodities in order to develop an appropriate empirical income distribution. Although the FISP program is substantially different from an area-yield program, to the public administrator the distinction between systematic and non-systematic risk continues to be important if he/she is concerned with program effectiveness.

Within the grain and oil seeds sector, grouping by crops and regions are made to

find meaningful relationships. In the FISP program meaningful groupings and statistical relationships would also need to be determined. Examples of meaningful groupings could be: cow-calf producers, hog producers (with possible further sub-groupings such as farrow to finish, farrow to weaner, and feeder operators), grain and oil seeds producers and feedlot operators. Once these groupings have been determined, sources of future prices would need to be found for the various commodities along with individual producer income records. Since the FISP program accepts applications up to July 31st of the following calendar year for which the benefits would be payable and governments within Canada have March 31st year-ends a need to estimate program liabilities would be required.

Another management requirement would be program evaluation. For both of these management requirements, a carefully designed empirical income distribution could be helpful to the public administrator. The correlation coefficient could measure the effectiveness of the FISP program with higher expected returns and lower standard deviations indicating lower variability. The identification of the systematic risk component would aid the public administrator in directing program funds to those variations in income caused by systematic risks.

Since the producers participating in FISP can alter their production activities (i.e., structural changes) to affect the probability or magnitude of a payment from the program, the problem of moral hazard needs to be considered. The single index model can be used to provide forecasts of estimated payments for various agricultural sectors. Individual producers who deviate significantly from this forecast could be set aside for further audit and verification. Once again, the tools of portfolio theory can be used to assist the public administrator.

Section 4 Conclusions

4.1 Summary of Study Objectives

Three objectives were listed in the introduction section for this paper. These objectives include: defining and explaining the term risk as it applies to public risk programs, reviewing methods of risk measurement and applying the tools of portfolio theory to public risk programs.

Risk, was defined as the variability of returns, as public risk programs tend to be concerned with reducing the variability of producer's incomes. This definition fits within the mean-standard deviation, or mean-variance criterion. It was further seen that the sources of public risk can be grouped into five categories, including: "(1) production or technical risk; (2) market or price risk; (3) technological risk; (4) legal and social risk; and (5) human sources of risk." (Sonka and Patrick 1984, 97)

For the second objective various risk measures were identified, including the variance, standard deviation, and the covariance. It was observed that some risk groupings were quantifiable while others were not. The portfolio model was examined as an approach which can be used to identify a set of efficient stock portfolios from all of the available securities within the marketplace. From portfolio theory, it can be determined that the effectiveness of diversification and the effective success in risk reduction was measured by the magnitude and sign of the correlation coefficient.

From investment theory, components of total variability were described in terms of systematic and non-systematic risk. The importance of this concept is twofold. First, an effective diversification strategy can reduce the unique risk and thus the cost of some public risk programs. Secondly, the systematic risk common to all farms is the risk which public programs should be designed to address. Cost estimates of these programs and

some key program management issues can be evaluated using the concept of systematic risk. The final risk measurement tool identified was the single-index model. This model assumes that the residuals for the different stocks are perfectly uncorrelated, allowing for an accurate estimate of the minimum variance.

For the final study objective, a review of portfolio theory for application to public risk programs was conducted. The three applications examined were crop insurance, area-yield options and companion stabilization programs. Problems within individualized crop insurance (i.e., rising costs, dropping participation, moral hazard and adverse selection) led Miranda (1991) to revisit area-yield insurance. Through the use of portfolio theory and specifically the ideas of systematic risk, an alternative area-yield insurance was proposed as a way of addressing these problems.

The second application considered was related to crop insurance and risk management tools which may be available to insurance providers. The specific tool was an area yield options contract, traded on public markets. This contract could be used to manage the yield risk accepted by insurance providers. Again it was seen that portfolio theory could be used to evaluate and measure that potential.

The third and final application reviewed was public revenue stabilization schemes currently being considered in Canada under the heading of companion risk programs. As in the previous cases, these programs involved potential claims to the program provider contingent upon uncertain income realizations from farming activities. As before, the program administrators were concerned with evaluating the potential payments which they may be required to make to their clients. Again, by understanding the characteristics of a portfolio, a reasonable estimate of future claims could be developed.

4.2 Recommendations

The results of the literature review indicate that area-yield insurance could potentially reduce the adverse selection and moral hazard problems found within individualized crop insurance. The comparison of results of the individual plan to the full coverage area plan and the optimal coverage area plan as summarized by Miranda, (1991) show that on average area insurance premiums are much lower than for individual yield insurance premiums. Subsequent to the Miranda article, Turvey and Islam (1995) state that in terms of efficiency in risk-reduction individual plans were superior to area plans while area yield insurance costs less.

A brief numerical example of the calculations required to evaluate an area yield program for Alberta was conducted for illustrative purposes. The area selected was the County of Lacombe. The crop used was canola. The results show that of the 25 producers in the sample, ten would have found area-yield insurance risk reducing, five would have found it to be risk augmenting and the implications for the remaining ten producers were uncertain. What this means for public risk program providers is an alternate program to the existing individual coverage presently offered to producers could be considered.

Area-yield insurance may achieve a more cost-effective approach to delivering crop insurance for some producers while at the same time providing additional risk-management options. The implementation of such a program would require a more rigorous look at the empirical side to assess the feasibility of implementation. Therefore the following is recommended:

1. Administrators of individualized insurance programs should conduct further

studies of area-yield insurance to assess the costs and benefits of an area-yield program as either a supplement or replacement to existing programs presently offered. The research project should include a review of the pilot work conducted by Jerry Skees from the University of Kentucky.

Miranda and Glauber (1995) propose that individualized crop insurance is ineffective. After isolating the systematic and non-systematic risk within the crop insurers portfolio they determine that risks are about ten times larger for crop insurers than for private insurers offering more conventional lines of insurance. The authors assert that "private crop insurance markets fail primarily because systemic weather shocks induce significant correlation among farm-level yields, defeating insurer efforts to pool crop loss risk across farms." (Miranda and Glauber 1995, 1) As an alternative to reinsurance in managing systemic agricultural risk, options and futures contracts could be considered since they could rise and fall inversely with changes in expected aggregate crop yields. Since no options and futures markets exist within Canada, a discussion of the potential for hedging instruments is probably academic. Nevertheless the following is recommended:

2. A review of existing Canadian markets for suitability and/or the creation of new Canadian markets should be conducted to see if Miranda and Glauber's proposed area-yield option could be applied in Canada.

The Farm Income Stabilization Program (FISP), as with the other previous programs, is discussed in terms of potential claims to the program provider that are contingent upon uncertain income realizations from farming activities. Therefore, program administrators are concerned with evaluating the potential payments which they may be required to make to their clients. These claims represent a portfolio to be managed by the administrators. By understanding the characteristics of the FISP portfolio, a reasonable estimate of future claims could be developed. The tools of

portfolio theory could be used to evaluate and manage the FISP claims. The single index model could be applied to prepare reasonable forecasts of program expenditures, thus assisting with the overall management of the program. Therefore the following is recommended:

3. Public administrators of the Farm Income Stabilization Plan should consider using the tools of portfolio theory to assist in the forecasting of program expenditures and in the overall management of the program.

In closing, the previous chapters contain a review of basic concepts and tools associated with portfolio theory and their applications to public risk programs. From this review it is determined that public risk programs are another type of portfolio to which can be applied traditional investment theory. The properties of a public risk portfolio parallel those of an investment portfolio in that the components of the variability can be described in terms of systematic and non-systematic risk.

In the literature reviewed for this study, it was established that systematic and nonsystematic risk satisfactorily decompose variability in portfolio problems. This observation leads one to believe that these concepts can be applied to any problem which has the characteristics of a portfolio, even if that problem does not superficially look like the standard financial market portfolio. The development and administration of public risk programs in agriculture is one such case where the assets in the portfolio are the claims arising from the activities of individual businesses. The central agency is faced with the problem of managing those claims which are by their very nature, uncertain. Portfolio theory and associated tools/models should prove to be useful in the assessment and management of these programs.

4. When an agency has a portfolio management problem they should consider using the tools of portfolio theory to evaluate and manage their claims.

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Appendix A: Proposal Estimate and Worksheet

NAME: Farmer X PHONE NUMBER: _____ DATE: 1993/94 Crop Year _____

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Appendix B: Yield Verification Project

Yield Verification

Introduction

Accurate information of crop yields is the key element in establishing an area normal yield, a producer's individual coverage, and indemnity payment. The existing GRIP program requires to measure all yields each year, and thus the yield verification process could be a potential area where cost savings may be realized through a more efficient approach.

One of possible alternatives is to take advantage of the reported yields, and consequently the question about accuracy of reported yield is raised. This project is conducted to make comparison between actual yields measured by adjusters and declared yields filed by the insured producers. The availability of both measured and reported yield data for 1991-1993 provides the basis for this project.

Research Questions

1. Does there exist substantial inaccuracy in yield reporting?

2. What could be the major sources of reporting inaccuracy if there is any?

Inaccuracy in yield reporting could be (1) the result of deficiency in yield estimation skills, and/or (2) the result of deliberate misreporting. Understanding of the mechanism generating misreporting is crucial for the decisions about how to calculate the cost of reporting inaccuracy and how to utilize reported yields in the process of yield verification.

3. How to determine that skill deficiency is not a major source of reporting inaccuracy?

Given the complexities of yield measurement, accidental estimation errors are expected to occur very frequently. As long as reporting errors are random and accidental, there should be no systematic patterns emerging from statistical analysis. In other words, propensity of over-reporting or under-reporting should not vary with factors that have potential to make insured producers benefit more from yield misreporting. Such factors include claim qualification, claim size, and index of coverage adjustment.

4. How to determine that deliberate misreporting is a relatively common occurrence?

It is also highly possible that insured producers may choose to report yield to their own advantage. If that is the case, it is expected that decisions about whether over-reporting or under-reporting would depend upon the perceptions of whether the insured producers are in a claim position. Producers are more likely to choose over-reporting yields when their production are perceived above coverage. Overestimation under these circumstances could improve their individual index of coverage adjustment and increase their chance and amount of claim in a long run. In contrast producers are more likely to choose under-reporting yields when their productions are perceived below coverage and thus they could take chance to collect more indemnity payments from the programs.

Even if misreporting is intentional, it is necessary to emphasis here that such behaviour does not imply the insured producers are less honest than other people as a whole. Rather, they might respond rationally to the incentives they confront in the system. They might be fully aware that there is no risk associated with benefiting from misreporting, because it does not appear possible to classify misreporting as a calculated action for an individual as long as yields they reported look plausible, or within a "reasonable" error range. However, the statistical modelling makes it possible to identify the existence and the pattern of deliberate misreporting if there is any.

Deliberate misreporting could be found as a major source of reporting inaccuracy if there is evidence emerging from data analyses to support the following hypotheses:

(1) It is hypothesized that how to report yields (i.e., whether to over-report or under-report) depends upon whether the perceived production is below or above coverage (i.e., whether in a claim position or not).

(2) It is hypothesized that how much to overestimate or underestimate depends upon how much the perceived production is above or below coverage.

(3) It is hypothesized that reporting behaviour is affected by producer's index of coverage adjustment.

Research Methods

1. Measurement of accuracy:

Accuracy of reported yield is measured by the discrepancy between measured and reported production, which is calculated for every crop insured during 1991 - 1993 by each customer as the following:

$$DM_gap = (D - M) / M * 100$$

where

D = total declared production in Kg without quality adjustment;

M = total measured production in Kg without quality adjustment;

DM_gap = (D-M)/M (%).

2. Claimed vs. unclaimed:

First, the claim qualification is defined as following:

$$CLAIM = C - D$$

where

CLAIM: claim qualification;

C: coverage = area normal * coverage level * coverage adjustment * acres;

D: total declared production in Kg without quality adjustment.

Then, all insured producers are categorized into two groups on the basis of the claim qualification defined above:

(1) if CLAIM > 0, the insured are in a claim situation (claimed);

(2) if CLAIM ≤ 0, the insured are not in a claim situation (unclaimed).

3. Overestimation vs. underestimation:

All the insured producers are also grouped on the basis of accuracy measurement, i.e., DM_gap. There is neither overestimation or underestimation involved if reported yield is equal to the measured (i.e., DM_gap = 0). It is overestimation if reported yield is above measured yield (i.e., DM_gap > 0) and underestimation if reported yield is below measured yield (i.e., DM_gap < 0).

Results and Discussions

1. The gap between the actual and reported yields:

Total discrepancy between actual and reported yields of 10 major crops is separately calculated for the following three groups: (1) the total insured population, (2) the unclaimed, and (3) the claimed. The results are presented in Table 1 and Figure 1.

The information about reporting accuracy of the total insured population could be quite misleading. With respect to the sign of inaccuracy, there is no clear direction of misreporting: underestimation of 7 crops in 1991, 1 in 1992, and 3 in 1993, while

overestimation of 3 crops in 1991, 9 in 1992, and 7 in 1993. There is only oats which is consistently underestimated for three years. In terms of size of inaccuracy, most crops are consistently found within 5% range for three years examined, with only 2 exceptions. These overall results seem to suggest that the reported yields are reliable enough, and that reporting inaccuracy, if there is any, is more incidental than intentional.

In contrast, a clear pattern emerges by breaking down the total insured population into claimed vs. unclaimed subgroups depending upon the perceptions of the insureds about their qualifications for claims. In terms of the sign of inaccuracy, most of crops are negative for the claimed (i.e., 21/30) and positive for the unclaimed (i.e., 21/30). In other words, underestimation dominates the reporting behaviour of the claimed while the unclaimed are overshadowed with overestimation. With regards to the size of inaccuracy, the effect of underestimation for the unclaimed is much more severe than that of overestimation for the unclaimed. Some of underestimation reach as high as 40% of the actual production.

The above results clearly document large differences in reported compared with actual production. The results also indicate that misreporting is systematically, not randomly, distributed across the claim eligibility. The consequent concern would be how to detect misreporting if yield verification is mainly based on the information of reported yield, which is the question addressed in the next section.

2. *Misreporting detection:*

The logistical regression model is employed to detect whether the probability of overestimation/underestimation is systematically related to the expected benefits of misreporting rather than randomly distributed among the insured population. Two variables are included in the analysis as indicators of expected benefits of misreporting: (1) distance to coverage, and (2) index of coverage adjustment. And two more variables are also included in the model to control variation in acreage insured and regions (see Footnote 1¹).

¹The general model estimated is the following one:

$$\log[P/(1-P)] = c_0 + c_1 (\text{Acres}) + c_2 (\text{CovAdj}) + c_3 (\text{ClnAmt}) + c_4 (\text{region2}) + c_5 (\text{region3}) + c_6 (\text{region4}) + c_7 (\text{region5}) + e$$

If the two variables of interest do not affect the probability of overestimation /underestimation, reporting inaccuracy can be mainly attributed to deficiency of yield estimation skills. However, significant impacts of the two variables on the probability of over-reporting /under-reporting are consistently demonstrated for three years investigated, as shown in Table 2. The evidence directs us to the conclusion that deliberate misreporting is not random event but a relatively common occurrence in yield reporting .

This finding has two implications for yield verification. First, the problem of misreporting could be getting worse in response to remove or reduction of yield adjustment mechanism from the program for two reasons. (1) All insured producers have always been advised for last three years that they would be measured shortly after declarations are filed (also, some declarations were completed when adjustors measured bins), which should have a positive impact on the accuracy of yield reporting. And (2) participation of GRIP discourages the insured farmers from over-reporting yields in the case of non-claim.

Secondly, in contrary to the typical approach to monitoring yield verification which treats all clients identically, the evidence of deliberate misreporting makes it possible to “discriminate” against those who tend to have above-average misreporting rates on the basis of eligibility of claim, distance to coverage and coverage adjustment. It appears that statistical profiles could be used to effectively identify high-risk versus low-risk groups in yield reporting for differential administrative scrutiny. This also requires more work to answer the questions such as how the insured to report yields to their advantages.

The logistical regression models are applied to the claimed and unclaimed groups

where

P	= Probability of overestimation (1 if overestimate, and 0 otherwise);
Acres	= acres insured for a crop;
CovAdj	= index of coverage adjustment
ClimAmt	= the amount below coverage or the amount above coverage, measured in percentage, formally, $(C - D) / D$;
region2	= 1 if the insured is in Region 2, 0 otherwise;
region3	= 1 if the insured is in Region 3, 0 otherwise;
region4	= 1 if the insured is in Region 4, 0 otherwise;
region5	= 1 if the insured is in Region 5, 0 otherwise;
e	= a randomly distributed error term.

The dependent variable in this case is a dichotomous one, and maximum-likelihood logistic regression analysis is thus an appropriate estimating technique.

separately. As shown in Table 2 and Figure 2, the two groups are consistently affected by the same variables in different ways.

The propensity of over-reporting/under-reporting is significantly increased when production is close to coverage, and reduced when production is far away from coverage. As shown in Figure 2a, 60-65% of the unclaimed producers in 1991 made overstatement of their production, 35-40% in 1992, and 45-50% in 1993 when their production is no more than 20% above their coverage. In contrast, 55-60% of the claimed in 1992 and 1993 made underestimation of their production, and 40-45% in 1991 when their production is no more than 20% below coverage, as shown in Fig 2b. It is worth noting that the probability of underestimation for the claimed does not decline as fast as the probability of overestimation for the unclaimed, which could be an explanation for the finding that the aggregate impact of underestimation for the claimed is more severe than overestimation for the unclaimed.

It is also shown in Table 2 and Figure 3 that a higher index of coverage adjustment is associated with a higher probability of overestimation in the case of non-claim, while index of coverage adjustment would not affect reporting behaviour of the claimed. The finding provides support for the argument that the producers in the position of no claim are concerned about building records for the future claims.

There is substantial difference among 5 regions for the unclaimed group but not for the claimed one. For example, the unclaimed producers in Region 1 are more likely to over-reporting than other regions. In contrast, the probability of under-reporting for the claimed group is not significantly among five regions.

Fig. 1. Inaccuracy of Reported Yields (%)
1991-1993

1991			
POP	overall	unclaimed	claimed
111	-0.71%	-0.02%	-14.02%
121	-9.34%	-4.94%	-25.32%
131	0.45%	1.84%	-8.88%
161	-0.01%	0.92%	-6.13%
111	0.55%	1.28%	-20.70%
211	-2.20%	-1.43%	-41.06%
711	0.08%	1.37%	-22.73%
311	-5.39%	-1.25%	-40.95%
611	-1.49%	-0.62%	-19.38%
311	0.65%	0.19%	-30.81%
age	-0.02%	-0.00%	-0.23%

1992			
POP	overall	unclaimed	claimed
111	4.36%	4.81%	1.90%
211	-1.79%	-0.94%	-4.38%
311	3.96%	4.20%	2.74%
511	2.95%	3.28%	1.19%
111	6.48%	7.30%	-0.98%
211	2.75%	3.09%	-2.62%
711	4.76%	5.06%	3.15%
311	2.51%	2.10%	5.67%
611	3.47%	3.72%	2.08%
311	3.34%	3.74%	1.06%
age	0.03%	3.64%	0.01%

1993			
POP	overall	unclaimed	claimed
111	3.14%	3.38%	-2.95%
111	-4.15%	-3.33%	-15.24%
111	2.43%	3.08%	-8.77%
111	2.34%	2.72%	-4.04%
111	3.88%	4.75%	-12.72%
111	-0.54%	-0.13%	-19.49%
111	2.03%	2.28%	-1.39%
111	-0.79%	-0.78%	-0.95%
111	1.28%	1.24%	1.76%
111	5.32%	5.50%	-1.11%
age	0.01%	0.02%	-0.06%

Fig. 1. Inaccuracy of Reported Yields (%)
1991-1993

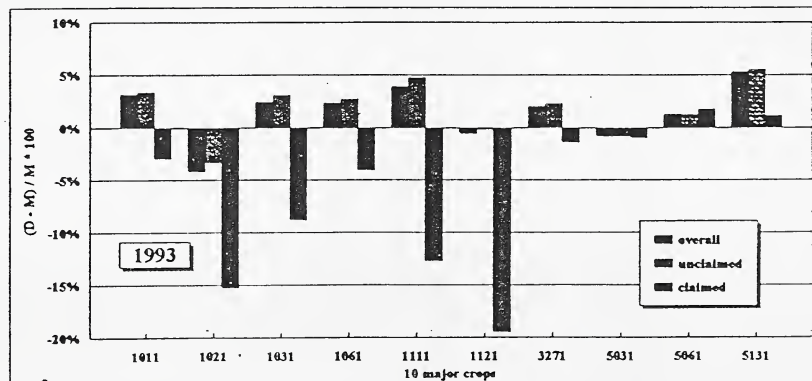
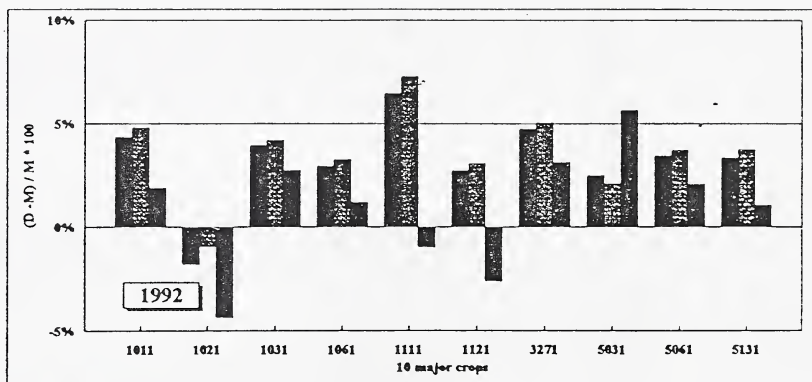
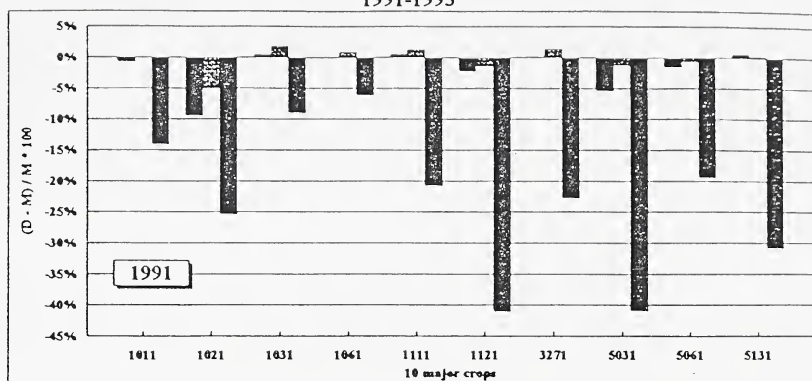
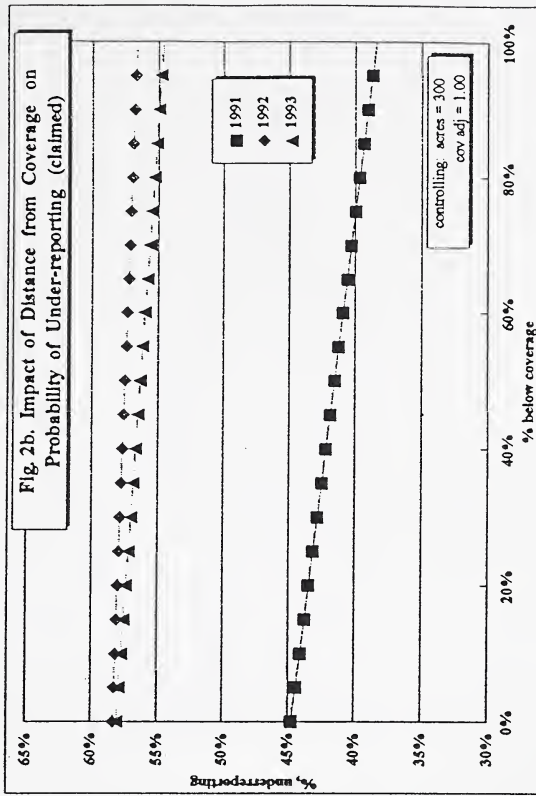
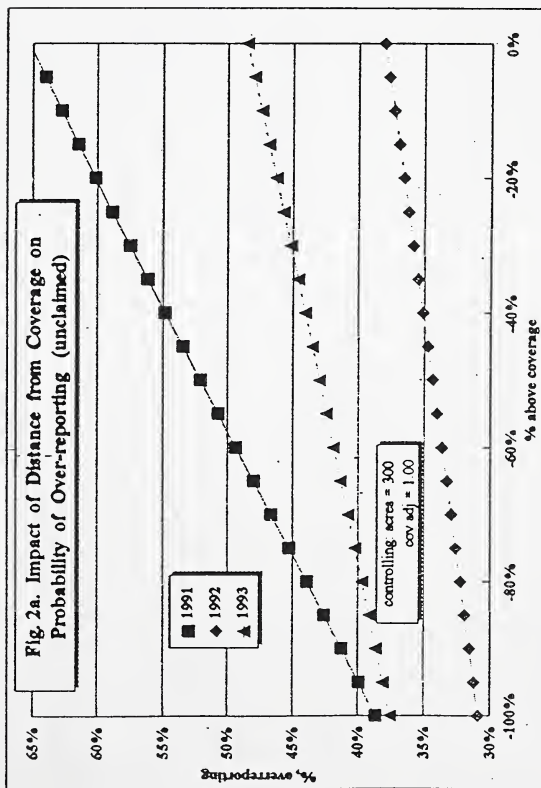


Table 2. Estimation Results of the Logistical Regression Model
for the Claimed and the Unclaimed
1991 - 1993

Variables	1991		1992		1993	
	unclaimed	claimed	unclaimed	claimed	unclaimed	claimed
Intercept	-0.1901 (0.1147)	-0.2357 (0.2660)	-0.7837 ** (0.1226)	-0.2781 (0.1957)	-0.2768 ** (0.1025)	-0.7352 ** (0.2847)
acres	0.0000 (0.0001)	0.0003 (0.0001)	-0.0004 ** (0.0001)	-0.0006 ** (0.0001)	0.0003 ** (0.00005)	-0.0005 ** (0.0002)
CovAdj	0.8218 ** (0.1078)	0.3569 (0.2313)	0.3885 ** (0.1191)	0.0933 (0.1737)	0.3092 ** (0.0976)	0.5323 (0.2493)
CovAmt	1.0936 ** (0.0961)	0.2605 ** (0.0394)	0.3201 ** (0.1080)	0.0682 ** (0.0231)	0.4496 ** (0.0870)	0.1377 ** (0.0370)
region2	-0.4725 ** (0.0355)	-0.0724 (0.0956)	-0.2492 ** (0.0409)	-0.2906 ** (0.0733)	-0.3748 ** (0.0360)	0.0112 (0.1107)
region3	-0.3100 ** (0.0388)	0.2097 (0.0909)	-0.0798 (0.0441)	0.0345 (0.0671)	-0.1695 ** (0.0367)	0.2041 (0.1170)
region4	-0.4080 ** (0.0535)	-0.0609 (0.1132)	-0.1608 ** (0.0614)	0.0048 (0.0881)	-0.3277 ** (0.0485)	0.0867 (0.1406)
region5	-0.5549 ** (0.0491)	-0.2332 (0.1245)	-0.0306 (0.0621)	-0.1916 (0.0987)	-0.3155 ** (0.0564)	-0.1117 (0.1281)
Summary Statistics						
Log Likelihood	359.93	107.87	91.1	78.3	162.37	36.66
degrees of freedom	7	7	7	7	7	7
number of observations	22388	4733	18541	7178	24452	3221

notes: (1) Parameters are listed first, and standard errors are listed in parentheses.

(2) Significant at the 0.01 level.



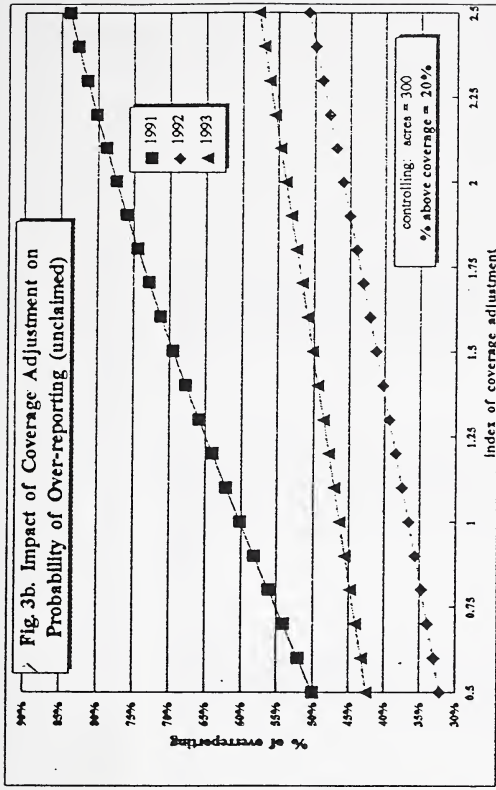
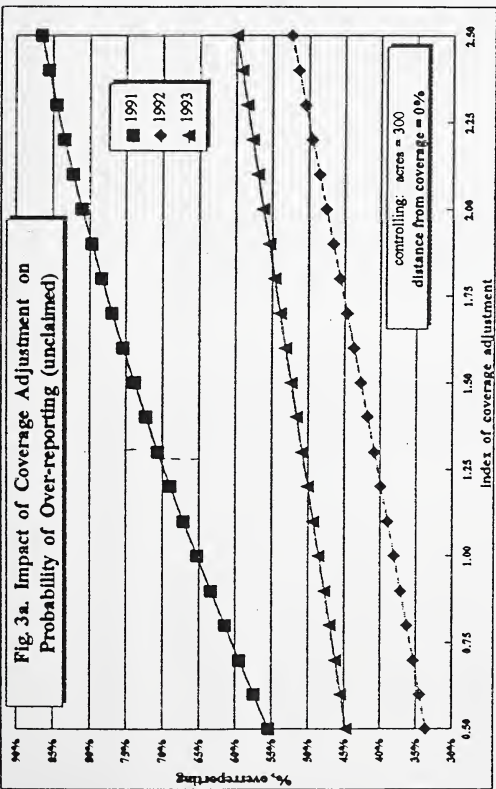


Table 3a. Estimation Results of the Multiple Regression Model
(the unclaimed group)
1991 - 1993

Variables	1991		1992		1993	
	under-report	over-report	under-report	over-report	under-report	over-report
intercept	-8.6254 ** (0.2020)	6.3604 ** (0.3410)	-8.5555 ** (0.2536)	12.7369 ** (0.3476)	-9.5183 ** (0.2556)	9.1647 ** (0.3590)
acres	0.0015 ** (0.0002)	-0.0039 ** (0.0004)	0.0019 ** (0.0003)	-0.0036 ** (0.0004)	0.0025 ** (0.0003)	-0.0022 ** (0.0004)
CovAmt	-6.1755 ** (0.4152)	-7.3973 ** (0.6631)	-5.4995 ** (0.5403)	1.9558 ** (0.7223)	-5.5751 ** (0.4501)	-2.5971 ** (0.6280)
region2	0.2361 (0.1638)	1.0739 ** (0.2687)	0.4242 (0.2169)	0.5691 (0.2850)	0.1416 (0.1962)	1.8027 ** (0.2704)
region3	0.5045 ** (0.1765)	0.8771 ** (0.2988)	1.0431 ** (0.2320)	-0.7093 (0.3168)	-0.0542 (0.1975)	0.4187 (0.2819)
region4	-0.0214 (0.2509)	0.9602 ** (0.3989)	0.3557 (0.3236)	0.2371 (0.4339)	-0.2701 (0.2658)	1.1382 ** (0.3609)
region5	-0.6347 ** (0.2371)	2.1108 ** (0.3545)	-0.8195 (0.3243)	2.2203 ** (0.4475)	-0.5834 (0.3107)	2.6816 * (0.4154)
Summary Statistics						
R-sqr (%)	2.48%	2.43%	2.59%	1.13%	2.65%	0.84%
number of observations	11074	11312	6227	12312	9657	14793

notes: (1) Parameters are listed first, and standard errors are listed in parentheses.

(2) Significant at the 0.01 level.

Table 3b. Estimation Results of the Multiple Regression Model
(the claimed group)
1991-1993

Variables	1991		1992		1993	
	under-report	over-report	under-report	over-report	under-report	over-report
Intercept	-14.5245 ** (0.9999)	10.1581 ** (0.7874)	-9.0240 ** (0.6220)	17.0199 ** (0.6699)	-12.1481 ** (1.3404)	15.0873 ** (1.1087)
acres	-0.0033 (0.0016)	-0.0068 ** (0.0014)	-0.0008 (0.0010)	-0.0022 (0.0009)	-0.0084 ** (0.0022)	-0.0042 (0.0017)
CovAmt	-2.5875 ** (0.1034)	0.7450 (0.3156)	-4.1364 ** (0.1847)	2.6529 ** (0.2462)	-2.0628 ** (0.1616)	1.8501 ** (0.5979)
region2	0.8681 (1.1619)	1.7282 (0.8768)	-0.4506 (0.7534)	0.0705 (0.7640)	-0.8584 (1.4900)	-0.2941 (1.1617)
region3	3.3930 ** (1.0753)	-0.2101 (0.8487)	0.8726 (0.6690)	-3.7574 ** (0.7324)	1.0147 (1.5409)	-0.1119 (1.2429)
region4	1.7804 (1.3793)	1.9507 (1.0353)	1.5522 (0.8740)	-5.2192 ** (0.9682)	-1.5608 (1.8756)	0.4269 (1.4968)
region5	4.4836 ** (1.5558)	4.2025 ** (1.1121)	1.9516 (1.0133)	-0.7116 (1.0336)	2.9474 (1.7485)	2.8689 (1.3159)
Summary Statistics						
R-sqr (%)	19.20%	3.10%	14.78%	4.39%	11.20%	2.42%
number of observations	2797	1934	2971	4205	1490	1729

notes: (1) Parameters are listed first, and standard errors are listed in parentheses.

(2) Significant at the 0.01 level.

Appendix C: Farm Income Stability Program

FARM INCOME STABILITY PROGRAM (FISP)

be eligible for a FISP payment. To determine if a claim is warranted, adjustments have to be made to the current year's program margin for things like inventory changes and deferred income.

- There is no premium cost to the farmer for FISP. However, there is a \$50 application fee, which **must** accompany any claim. In addition, 1% of any claim to a maximum of \$450, will be withheld for administration (\$2250 in the case of a Corporation with five shareholders).

A. WHAT IS FISP?

- FISP is one component of a package of agriculture safety net programs available to Alberta farmers. **It is new for the 1995 tax year and is administered by Agriculture Financial Services Corporation (AFSC).**
- FISP was developed with input from Alberta farmers and is designed to comply with international trade agreements.
- FISP is a whole farm program, which means all agricultural commodities are eligible. It is designed to work closely with income tax so much of the information you will already be calculating can be applied to this program.
- FISP provides a measure of stability against fluctuation in your farm's **program margin**. Your **program margin** is the difference between selected farm revenue and expenses. Off-farm income is NOT included in FISP.
- If your current year program margin falls below 70% of the average of

NISA has triggers which are currently set at 100% and therefore primarily cover the more predictable income variations.

- Crop Insurance provides protection against production shortages due to natural perils. Its use as a financial risk management tool remains the same. Payments from crop insurance are included in revenue under FISP and premium costs are an eligible expense.

- NISA

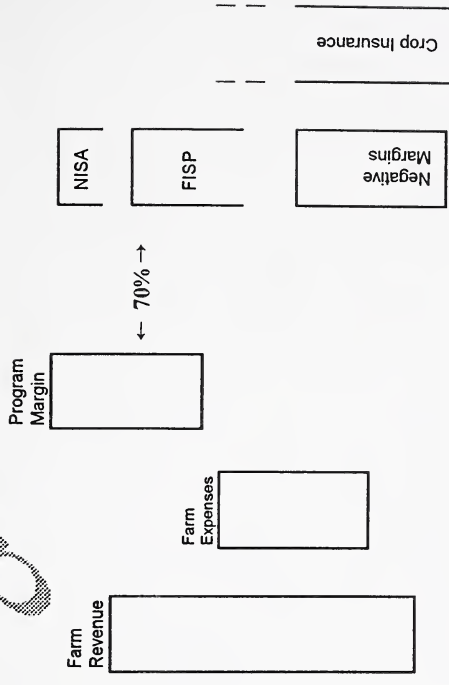
is still available in its current form. Any government contributions in your NISA account up to and including the 1994 tax year have NO LINK to FISP. However, for the 1995 tax year and beyond, any government contributions to your NISA account will be deducted, on a one year lag basis, from any FISP payment. For example, if you were to make a claim under FISP for the 1995 tax year, government contributions to NISA for the 1995 tax year would NOT be deducted from a FISP payment.

How do the Components Work Together?

Alberta's package of safety net programs are intended to protect farmers from abnormal income declines. Figure 1 outlines the general concept and shows where each component operates.

FISP covers situations where your current year's program margin falls below 70% of the reference margin (average of three previous years program margins). However, it DOES NOT cover negative margin situations—the area where expenses become greater than revenue. Crop insurance is the only component which may cover a negative margin situation, and depending on the coverage elected, may even work above the negative margin area.

Figure 1



B. HOW DOES FISP WORK?

Remember, if your current program margin falls below 70% of the average of your previous three years program margins (known as the Reference Margin), you may be eligible for a FISP payment. To determine if you are in a claim position, some adjustments have to be made to the current year's program margin. These adjustments include things like value of inventory change and deferred income.

You only need apply to FISP in the year of a claim. This program does not require annual premiums, annual administration fees, or applications. However, in the claim year you must provide details for your farm's reference margin and current year's program margin.

Example Calculation of Reference Margin:

Year	Revenue	Expenses	Annual Program Margin
1992	100	60	40
1993	95	65	30
1994	115	65	50

Reference Margin $(40+30+50) / 3 = 40$

Support margin is 70% of the reference margin.

Support Margin $= 40 \times 70\% = 28$

Now, let's use the same support margin and show what happens in two different claim scenarios.

Scenario 1: Current program margin falls but **REMAINS POSITIVE**:

Current Year	Revenue	Expenses	Program Margin
1995	80	60	20

FISP payment is the difference between support margin and current year margin:

$$28 - 20 = 8$$

Scenario 2: Current Margin in current year and **GOES NEGATIVE**:

Current Year	Revenue	Expenses	Program Margin
1995	40	60	-20

FISP payment is the difference between support margin and current year margin, but since FISP does not cover negative margins, the payment is: $28 - 0 = 28$

A zero is used for current program margin to calculate the FISP payment rather than the actual -20. **FISP DOES NOT PAY FOR NEGATIVE MARGINS.**

Adjustments to the Claim Year Program Margin

After the basic calculation of the claim year program margin is completed (information from the tax form) there are two adjustments that are required.

1. The net change in the value of inventory (difference between beginning and year-end inventory) is added to the program margin. Both beginning and ending inventories **MUST** be valued with the same prices. The result can be positive or negative—if positive, it is added to revenue, and if negative, it is subtracted from revenue.
2. The net change in the value of deferred payments are added (or subtracted) from the current year program margin. Examples of items in the deferral category include: crop insurance receipts, accounts receivable, and accounts payable.

What Happens if I Don't Have Three Years History?

For the purpose of FISP, a beginning farmer is anyone who makes his claim to FISP in a year he begins farming. In these situations, there is no history on which to establish a reference margin. A three year reference margin will be calculated with the help of program administrators based on the same farm structure that exists in the claim year (see your district AFSC office for more details).

Any farm operation that does NOT have a complete three year history in its first claim year will use the years which are available and the corporation will calculate the program margin for the missing years.

The program margin is calculated for both the claim year and three year reference period. However, adjustments to the claim year program margin for inventory change, deferred income and accounts payable are required. No adjustments are required for each of the program margin calculations that make up the reference margin figure.

Program margin is the difference between selected farm revenue and expenses. Eligible farm income includes all revenue from farming, excluding machinery rental and crop share. Off-farm income is not included. Eligible farm expenses are all expenses from the tax form (T2042) **excluding**:

- Clearing, levelling and draining land expenses
- Interest
- Machinery rental
- Property taxes
- Rent (land, buildings, pasture)
- Non-arm's length salaries
- Optional inventory adjustment
- Mandatory inventory adjustment
- Capital cost allowance
- Allowance on eligible capital property

Why are some revenues and expenses excluded?

Under GATT rules, governments cannot base *agricultural* safety net programs on off-farm income. Exclusion of other elements ensures that the program does not influence farm production and purchase decisions, and limits capitalization into land values. For example, in order that the program does not influence 'buy' versus 'rent' decisions for farm machinery, both rental costs and depreciation are excluded.

... OR TO MY PROTECTION?

Yes. Governments have limited financial resources for all programs and FISP is no exception. In addition, to keep FISP as simple as possible, it is designed to administer applications in claim years only. Premiums are not required, nor are annual administration fees or record filings to program administrators. This keeps the cost down to farmers, but also limits the pool of revenue available to the program.

There are several aspects of the program that can limit either the protection you receive or the size of a potential payment.

Payment Limits

1(a) *Individual* - No individual can receive more than \$100,000 in any year from the FISP program. This limit is based on the program paying:

- 100% of the first \$50,000 of an annual claim AND
- 50% of the next \$100,000 of an annual claim.

1(b) *Corporate* - A similar limit is placed on corporations so that no corporation can receive more than \$500,000 in any year. The limit is based on the program paying:

- 100% of the first \$250,000 of an annual claim AND
- 50% of the next \$500,000 of an annual claim.

NOTE: Corporations with two shareholders are limited to two times the individual limit, and so on to a maximum of a five shareholder corporate limit.

1. *Negative Margin Shortfalls* - FISP does not protect against negative margin shortfalls (already discussed in Section B).

2. *Expanding Farm Size* - The program makes no adjustments to the protection offered an operation that has recently expanded. The reference margin will reflect your new size fairly quickly since it is based on a three year average.

3. *Declining Farm Size* - FISP is not intended to make payments that result from a declining farm size. If expenses IN A CLAIM YEAR drop by more than 15% compared to the average expenses from the previous three years, an automatic adjustment is made to the reference margin. The adjustment only applies to every percentage decline IN EXCESS OF the allowable 15% sleeve.

Example:

Year	Revenue	Expenses	Margin
1	100	60	40
2	95	65	30
3	115	65	50
4	60	35	25

In this example, expenses have decreased from an average of 63 $[(60 + 65 + 65)/3]$ to 35. This represents a decline of 44 percent, well beyond the allowable limit of 15 percent. The reference margin has to be adjusted downward by:

$$44\% \text{ (total decrease)} - 15\% \text{ (allowed sleeve)} = 29\%$$

$$\text{Reference Margin} = 40 \times (1.0 - 0.29) = 28.40$$

$$\text{Support Margin} = 28.40 \times 70\% = 19.88$$

There will be no FISP payment, since the current year's (Year 4) program margin (25) is greater than the adjusted support margin (19.88).

4. *reference margin calculations* - Payments from FISP are NOT eligible as revenue for future reference margin calculations. Negative margin figures that do occur ARE used to calculate future reference margins even though FISP does not cover negative margins.

included in your FISP application kit). Claims must be postmarked by July 31st of each year.

4. Each claim to FISP will be verified by program administrators and a percentage will undergo audits. Make sure you keep any additional information you used to calculate your claim until your claim is finalized and you receive payment.

5. *Prorating* - Government contributions to FISP are limited on an annual basis and the FISP fund cannot go into a deficit. While the program design features that limit payments and protection decrease the program liability, there may be extreme situations that could drain the fund's resources. In these rare circumstances, FISP cannot go into a deficit position and payments to claimants in such a year would be prorated.

D. HOW DO I APPLY?

Follow these steps to determine if you have a claim under FISP:

1. If you feel that you may be eligible for a claim, pick up an application form for FISP at your nearest AFSC district office.
2. Use your tax forms and other related information to complete the required schedules in the FISP booklet. This can be done after you have completed your taxes or simultaneously (check with your accountant).
3. If you have qualified for a payment send in the ENTIRE FISP booklet with all appropriate schedules completed to AFSC headquarters in Lacombe (a self-addressed envelope will be

With FISR in operation, many farmers who grow insurable crops will ask why they need to pay a premium for crop insurance. Crop insurance is a voluntary program and in the end, the choice is up to you. However, there are a number of reasons why any grain farmer should include crop insurance in their risk management strategies.

- FISP does not cover negative margins, so there is a substantial amount of risk left unprotected.
- Crop insurance is a crop specific program as opposed to whole farm. This means that a loss on one crop can still generate a crop insurance payment even though other crops or farm enterprises may have done well.
- Payments from the crop insurance program are prompt in relation to those from other programs, including FISP.
- Crop insurance is a production insurance program. Increasing prices do not decrease the potential for receiving benefits like they do in a whole farm program.
- Crop insurance payments are included as revenue for future FISP calculation of the reference margin. Consequently your support level could be higher in future years than without crop insurance.
- Crop insurance has built-in spot loss features, like the hail endorsement, rescinding benefit, and unseeded acreage provisions. Losses from many weather perils that only impact a portion of the farm operation would

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